THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL

VOL. 49. Thursday, January 12, 1933. No. 856.

PUBLISHED WEEKLY.

Subscription Terms: 15s. per annum.
Foreign and Colonial: 17s. 6d. per annum.
All Subscriptions are payable in advance.

All Communications to be addressed to the Editor, the Advertisement Manager, or the Publisher of

THE FOUNDRY TRADE JOURNAL,
49, WELLINGTON STREET, LONDON, W.C.2.

Telegraphic Address: "Zacatecas, Rand, London."
Telephone: Temple Bar 3961 (5 lines).

Contents.

	PAGE
Forthcoming Events	17
Founding and the Steel Industry	17
Furnaces: An International Survey	17
May Lecture	18
Book Review	18
District Presidents, No. 11	18
Notes from I.B.F. Branches	18
Random Shots	18
Nitricastiron	19
Some Experiences with the Balanced Blast Cupola	21
Steel for Steel Castings	22
Some Aspects of Selection of Engineering Materials	25
New Demands on the Brass Foundry	27
Hardening and Tempering Vanadium Steels	28
Solid-Woven Rubber-Impregnated Belting	28
Oil Engine Foundry Practice	29
This Week's News in Brief	30
Trade Talk	30
Personal	30
Obituary	30
Contracts Open	30
Company Meeting	30
Raw Material Markets	32

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES' EQUIPMENT AND SUPPLIES ASSOCIATION.

Institute of British Foundrymen.

PRESIDENT: 1932-33:

Victor Stobie, M.I.E.E., Langholm, South Drive, Harrogate.

LIST OF SECRETARIES—

General Secretary: T. Makemson, Saint John Street Chambers, Deansgate, Manchester. London Office: 49, Wellington Street, London, W.C.2.

Birmingham, Coventry and West Midlands: L. W. Bolton, 21-23, St. Paul's Square, Birmingham.

Sheffield: T. R. Walker, 33, Ladysmith Avenue, Nether Edge, Sheffield.

Scottish: J. Bell, 60, St. Enoch Square, Glasgow.

Lancashire: J. E. Cooke, 1, Derbyshire Crescent, Stretford, Manchester.

London: H. W. Lockwood, Stewarts & Lloyds, Limited, Winchester House, Old Broad Street, London, E.C.2.

Newcastle-upon-Tyne: J. W. Eckford, 4, Mosley Street, Newcastle-upon-Tyne.

East Midlands: H. Bunting, 82, Otter Street, Derby.

West Riding of Yorkshire: S. W. Wise, 110, Pullan Avenue, Eccleshill, Bradford.

Wales and Monmouth: J. J. McClelland, 12, Clifton Place, Stow Hill, Newport, Mon.

Middlesbrough: F. A. Harper, "The Briars," Bishopton Road, Stockton-on-Tees.

Foundry Trades' Equipment and Supplies Association.

President: D. H. Wood.

Titan Works, Charles Henry Street, Birmingham.

Secretary: K. W. Bridges, Grand Buildings, Trafalgar Square, London, W.C.2.

Welsh Engineers' and Founders' Association.

Secretary: E. J. Griffiths, 2, Royal Metal Exchange, Swansea.

BRITISH CAST IRON RESEARCH ASSOCIATION.

The Registered Office and Laboratories of the B.C.I.R.A. at :—

21-23, ST. PAUL'S SQUARE, BIRMINGHAM.

Telephone: Central 1886. Telegrams: CIRA.

The B.C.I.R.A. Scottish Laboratories are :—

Foundry Technical Institute, Meek's Road, Falkirk (*Telephone 332*).

Forthcoming Events.

JANUARY 17.

Institute of Marine Engineers:—Ordinary meeting. "Oxy-Acetylene Welding," Paper by H. P. Smith.

JANUARY 18.

Institution of Welding Engineers (London Branch):—Ordinary meeting. "Welding in Civil Engineering," Paper by C. Helsby.

JANUARY 19.

North-East Coast Institution of Engineers and Shipbuilders (Tees-side Branch):—General meeting. "Casting for Cunarder," Paper by F. Swift.

JANUARY 20.

Institution of Welding Engineers (Birmingham Branch):—Ordinary meeting. "Welding Cast Iron and Ferrous Alloys: Some Metallurgical Considerations," Paper by J. G. Pearce.

Institute of British Foundrymen.

JANUARY 13.

Middlesbrough Branch:—Ordinary meeting. "Notes on the Cause and Prevention of some Common Defects in Steel Castings," Paper by C. Howell Kain.

JANUARY 14.

Scottish Branch:—Ordinary meeting at Glasgow. "Foundry Problems."

JANUARY 20.

Sheffield and District Branch:—"Cupola Control: Its Progress and Value in the Iron Foundry," Paper by E. Wharton.

JANUARY 21.

Scottish Branch (Falkirk Section):—Ordinary meeting. "Furnace Linings," Paper by J. F. Hyslop.

Founding and the Steel Industry.

We have often deliberated on the extent to which a prosperous iron and steel industry is essential to a prosperous founding industry. Everybody will agree that the founding industry cannot flourish, for example, without a prosperous engineering industry. Newly-developed countries have quite flourishing foundries before they cultivate an extensive iron and steel industry, but after careful thought we are of the opinion that the founding industry of this country demands a prosperous steel industry. Foundries as a whole could not do so well if we became wholly importers of pig-iron and semi-manufactured steel. By tradition and by present organisation the industry is adapted in part to meet the demands of an active heavy industry in coal, iron and steel, and, although the founding industry is not usually considered to come within the scope of the reorganisation proposals which are now under discussion in the steel trade, it is very interested in them. Also, the starting up of a basic-steel plant in Northamptonshire should have very favourable reactions on the foundry trade.

Some of the most interesting proposals put forward for the replanning of the British steel industry were advanced during 1932 by Mr. Fred Clements. He showed by analysis that home prices ruling in Belgium for steel, and import prices in this country have no relation to the cost of manufacture. He gave ten million tons per annum of steel ingot as an output giving reasonable production efficiency to British steel-works. The re-rolling industry formed a special problem. He pointed to our superiority in the production of record-breaking engines, as evidence of our ability to produce the highest grades of steel, and emphasised the value of our integrity and reliability of product in foreign markets. He doubted if we could ever produce mass-production steel at prices which would enable us to compete with Continental mills; he hinted at the possibility of the adoption of a four-shift system.

Summarising briefly his proposals for reform, he suggested the revision of share capital to accord with present-day values and profit-earning possibilities; the establishment of a central co-operative control company to cover the whole of the steel-producing plant in the country, having a simple constitution and flexible working, the income for this to be derived by levy on pig-iron and steel produced. This central body would undertake international negotiations, deal with all export business, allocate production quotas and fix minimum basis selling prices in the home market. It would practically determine what plant would make particular products and the construction of new plants.

Furnaces: An International Survey.

Any examination of furnace practice based on an international survey reveals the most contradictory tendencies. For the production of non-ferrous alloys, we judge the situation to be as follows: In Great Britain, the progress made by the oil-fired reverberatory furnace is the outstanding feature; in France, the coke-fired crucible still holds the field, whilst in America, it is the induction-electric furnace which holds the premier place. In Germany, the situation is more open, and all types of furnaces are used, with no particular one outstanding. For the production of high-grade cast iron, the situation is equally complex. In Great Britain, the rotary pulverised-fuel-fired furnace is undoubtedly assuming important proportions; in America, the field is covered by stationary air furnaces and the electric-arc furnace. In France, the executives are satisfied that a very simple cupola is all that is needed, but rotary receivers are gaining ground, whilst in Germany the situation is somewhat similar to Britain, except that more attention is given to receivers having auxiliary heating. For the economic production of hot-fluid cast iron, the British probably lead with the balanced-blast cupola.

For the production of steel for foundry purposes, the most striking factor is the decline in popularity of the baby Bessemer in the United States, where its production is probably now but 5 per cent. of that made by the electric process. At a guess, we would say that in Europe the former process is holding its own.

It must not be thought that these differences are due to any national prejudices, as in practically every case quite feasible reasons can be found. Cheapness and purchase restrictions of electric current; guarantees given by furnace designers; suitability and cost of local labour and local specifications; price and availability of scrap and other raw materials; inherent skill

of the workers, competence of the metallurgical control, are all factors of paramount importance. Yet, as the economic conditions of any one country are not invariably applicable to every district comprising it, it behoves manufacturers of all nations to ascertain whether their local conditions more closely resemble those of their own country or foreign ones.

There must be many districts abroad still using the crucible furnace which could usefully follow current British or American tendencies, whilst no doubt there is room for an extended use of the electric furnace in British foundry practice.

May Lecture.

The President of the Société des Ingénieur Civils de France, Mr. Albert Portevin, has accepted the invitation of the Institute of Metals Council to give the next Annual May Lecture before the Institute. Mr. Portevin has chosen as the title of his discourse: "Quenching and Tempering Phenomena in Alloys." The lecture will be delivered on Wednesday, May 10, at the Institution of Mechanical Engineers, Storey's Gate, Westminster, commencing at 8 p.m. Visitors are invited. Cards of admission are obtainable from the Secretary of the Institute of Metals, who reports that applications for membership are flowing in much more freely than was the case when England was on the gold standard. Over 30 per cent. of the new members reside in U.S.A., where the Institute's subscription rate, when converted into dollars, looks particularly attractive.

It is announced that persons elected during the next few weeks have the privilege of membership not for the usual 12 months but for the extended period ending June 30, 1934. Membership forms can be obtained on application to 36, Victoria Street, London, S.W.1. The Institute, which this year celebrates the 25th anniversary of its foundation, will hold its annual general meeting in London on March 8-9. Upwards of a dozen Papers will then be presented for discussion. In the evening of March 8 the annual dinner will be held under the chairmanship of Sir Henry Fowler, K.B.E., LL.D., D.Sc., the President of the Institute. Sir Henry is now in Egypt attending the International Railway Congress at Cairo.

Book Review.

Mechanical World Year Book for 1933. Published by Emmott & Company, Limited, 31, King Street West, Manchester. Price 1s. 6d. net.

It should be appreciated by the reader that the difficulty for the Editor of this excellent little book is not what to include but what to exclude. If it gets too thick, it defeats its own end of being of handy size. The section devoted to cast iron now includes the B.S.I. specification, and we think it would have been useful to have indicated its serial number.

In connection with malleable cast iron, reference is made to Special Process (Crowley), showing the highest tests of all. Yet we think it should be deleted, as the foundry bearing that name no longer appears in standard lists of foundries.

We are pleased to see that the description "semi steel" has disappeared. The foundry industry is now very interested in mechanical handling, and much information and data are given. Whilst Mr. Tate's excellent notes on belt conveyors is retained, we think this section might be extended to include apron scraper and a few other types. That this need is realised is shown by the inclusion of a new section on bucket elevators. We strongly recommend this year book to our readers as being really good value for money.

District Presidents.—No. 11.

CHELMSFORD ENGINEERING SOCIETY.

The Chelmsford Engineering Society is fortunate in having for its President this year Lt.-Col. C. Hardie, D.S.O., the general manager of Crompton, Parkinson, Limited, as he is a man of wide business experience and charming personality. Col. Hardie was educated at Westminster School and University College, London. He received his practical experience at Messrs. Swan, Hunter & Wigham Richardson, of Newcastle-upon-Tyne, Messrs. Dick Kerr & Company, Limited, of Preston, and at sea. For the whole of the war period he was on active service, mainly in France. For this, after being mentioned in despatches twice, he received the D.S.O. Since the war he has been assistant general manager to the English Electric Company, and since April, 1928, general manager of

COL. HARDIE, D.S.O.,
President of the Chelmsford Engineering Society.

Crompton, Parkinson, Limited. He is also a director of the British Electric Transformer Company. Under his chairmanship, the Chelmsford Engineering Society is making great progress, and large and enthusiastic gatherings are regularly being held.

Notes from I.B.F. Branches.

Scottish Branch, Falkirk Section.—About 40 members of the Falkirk Section of the Scottish Branch of the Institute of British Foundrymen accepted the invitation of Messrs. Smith & McLean, Limited, to visit their steelworks and sheet-rolling mills at Gartcosh on December 9. The party was received and welcomed by Mr. Herbert Beard, director, and Mr. W. Bryden, works manager. After being conducted round the works the members of the party were entertained to refreshments in the works canteen. Mr. William Walker, vice-chairman of the Falkirk Section, in the unavoidable absence of Mr. T. Shanks, the chairman, thanked the directors for granting permission for the visit and for their hospitality, and Mr. Bryden and his staff for the manner in which they had received the party and for their efforts to make the visit interesting and instructive. Mr. Herbert Beard replied to the vote of thanks, and on leaving each member of the party was presented with an ash tray made from stainless steel sheet rolled by Messrs. Smith & McLean, Limited.

Random Shots.

One of these days "Marksman" is going to bring out a revised version of "Robinson Crusoe." The title of the Defoe classic will be retained, and perhaps even the leading character too; so that in this age of Hollywood adaptions the revision will not appear to be too drastic.

* * *

Robinson Crusoe will be a foundry manager shipwrecked on a desert island. The vessel in which he sailed will carry as part of its cargo a big shipment of foundry equipment. Man Friday will be a coloured man who served his time in the moulding shops of Alhabama. Together they erect a foundry and specialise in producing cast-iron pots for the cannibals on neighbouring islands. Towards the end of the story a young long-distance flier (feminine, beautiful and very rich, of course) will be forced to land on the island, owing to a cracked cylinder in the engine of her machine. Robinson Crusoe will replace the faulty component, and the two will then start off on their flight to New York, leaving Friday as sole proprietor of the Robinson Crusoe Foundry Corp., Inc. Readers should note that the pantomime and film rights of this story will be strictly reserved to the author.

* * *

"Marksman" had a friend once whose chief interest in life was motion studies. His stopwatch he held dearer than the American tourist does his moving-picture camera. He knew to a fraction of a second how long it should take an engine-worker to fill a pint tankard; and how long it would take an average thirsty commercial traveller to empty same. His enthusiasm was his undoing. He chose as a subject for his timing studies an Irishman who did things with a hammer. The Irishman was a slow worker. He actually took 0.65 second to strike a blow with his hammer. "Marksman's" friend repeatedly told him that 0.6 second was the limit for this operation. One day the Irishman lost his temper, let fly with his hammer, took only 0.5 second to do so. This is the friend's obituary notice.

* * *

One of the principal railway systems in this country has announced its intention of abolishing a number of those familiar little notices that at present adorn its passenger compartments. It would be a fine gesture on the part of the nation if the Poet Laureate were to be requested to address a funeral ode to these travellers' friends of many years' standing. It does indeed plunge "Marksman" into profound sorrow to know that soon he may no longer happen upon his old companion "For light articles only," that at this very moment workmen may be removing the last remains of that mellow acquaintance, "To lower window pull strap towards you." The same fate awaits other members of that gallant company—"Five seats," "It is dangerous to lean out of the window."

* * *

It was Doctor Samuel Johnson (was it not?) who once drank a score or more cupfuls of tea in the course of a single evening, much to the astonishment of Messrs. Boswell et Cie. The doctor has had many imitators since his dictionary was published, and it may be that he it was who first made tea drinking so popular in this country. The Empire Marketing Board has stated, in a recent report, that we drink six times as much tea as we drink coffee, whereas the United States drinks sixteen times as much coffee as tea. Is there any explanation for this trans-Atlantic difference in tastes? It may be that a large percentage of the coffee made (but not always drunk) in this country is not really coffee but a coloured liquid masquerading under the name, so that we fight shy of it.

"MARKSMAN."

Nitricastiron.*

CAST IRON SUITABLE FOR HARDENING BY THE NITROGEN-HARDENING PROCESS.

By J. E. Hurst.

A great deal of interest has been aroused by the development of cast iron suitable for nitrogen-hardening treatment. This is the most recent addition to the category of hardenable cast iron and is an alloy cast iron suitable for case-hardening by the nitrogen-hardening process. This process in its application to steel is now familiar to most engineers under the name of the Nitrarding process and the special alloy steels suitable for the process are known as Nitralloy steels. As in the case of the special steels, the essential alloy additions present in Nitricastiron, and to which it owes its susceptibility to the nitrarding process, are aluminium and chromium. The chemical composition and properties of aluminium-chromium cast iron within the range of commercial Nitricastiron have been described by the Author in a Paper before the May meeting of the Iron and Steel Institute last year. A typical chemical composition is as follows:—Total carbon 2.75, silicon 2.75, manganese 0.75, phosphorus 0.10, aluminium 1.75 and chromium 1.75 per cent.

Nitricastiron, as compared with ordinary cast iron, in all cases shows a higher strength, a higher modulus of elasticity, a lower permanent-set value and a greater intrinsic hardness. Nitricastiron is susceptible to heat-treatment by hardening and tempering and is also distinctly air-hardening. When exposed to the action of anhydrous-ammonia gas at a temperature of 500 deg. C., under the conditions of the commercial nitrogen-hardening process, it is accompanied by surface hardening and a diamond hardness value of 982 is attained. This value is much harder than glass and quartz and somewhat less than that of a beryl. A depth of penetration of 0.018 in. on the centrifugally-cast specimens was obtained with a 90-hr. treatment under standard conditions.

Type of Furnace Used.

The furnaces used are of the electrical-resistance type provided with automatic regulation features. The articles treated are placed loosely in a gas-tight box without any packing material. The box is provided with inlet and exit tubes for the passage of the gas. With the current of gas flowing at a pressure of about ½ in. to 1 in. water-gauge and maintained at a temperature of 510 deg. C. the ammonia undergoes dissociation and some of the nitrogen is absorbed by the articles, the exhaust gases passing from the box consisting of undissociated ammonia, hydrogen and some nitrogen. Control of the process is exercised through the extent of this dissociation. This is periodically checked throughout the process and maintained by adjusting the flow of gas at a value of approximately 30 per cent. dissociation. If the dissociation value is too low the current of gas is retarded, if too high the current of gas is increased. The temperature control is maintained by automatic regulation to within plus or minus 5 deg. C.

Selective Hardening.

Selective hardening can be effected by the use of tinning or the application of protective paint to the surfaces required to be maintained soft. Tinning is performed utilising a good lead: tin solder applied to the surfaces after cleaning and treating with zinc chloride flux. Excess of tin coating is undesirable and is removed by wiping the surfaces during the operation. Protective paints, made up of powdered aluminium and sodium silicate or chromic oxide and sodium silicate, are also effective. Such paints are generally applied with a brush, and the articles thus painted require to be thoroughly dry before submission to the nitrogen-hardening treatment. These paints can be removed readily after the hardening treatment by the application of boiling water.

The duration of the hardening treatment is about 80 hrs., and with this a depth of penetration of over 0.015 in. is obtained. Where depth of penetration is unimportant a shorter period can be adopted and treatments of 40- to 60-hrs.' duration are quite common. After this treatment the articles are allowed to cool and no further treatment is necessary to render them hard. The extreme outer skin shows a matte-grey colour, and for a depth of approximately 0.001 in. the surface is of a soft friable nature, which can be removed readily by simple operations such as polishing or grinding when the surface of maximum hardness is revealed. Whilst the best results, in so far as hardness and depth of penetration are obtained by hardening castings having their surfaces finely machined or ground, quite satisfactory results have been obtained in individual cases by hardening unmachined castings whose surfaces have been prepared by sand blasting. The results obtained under these conditions are somewhat inferior to those obtained with machined surfaces, but they have been found quite satisfactory for particular requirements.

Type of Surface Given.

The hard case-hardened surface is perfectly coherent and free from liability to spalling and flaking. This is demonstrated by the absence of such spalling effects in the diamond-hardness impressions made during the hardness determinations and also the absence of such effects when testing hardened specimens in bending for the determination of the ultimate breaking strength. It is considered by many people that the presence of graphitic areas are distinctly advantageous in surfaces called upon to withstand wearing action.

This stability of the case-hardened surface is definitely superior on castings which have been hardened after subjection to a preliminary heat-treatment. Two heat-treatments are available; the simpler of the two consists of heating the castings to 900 deg. C. and allowing to cool in still-air. The second heat-treatment consists of oil-hardening and tempering which is carried out by quenching the castings in oil from a temperature of 850 to 875 deg. C. and tempering at a temperature of 600 to 650 deg. C. The effect of this treatment is to convert the pearlite into the sorbitic or spherodised condition. Incidentally, in this condition the structure of Nitricastiron is similar to the spherodised cast irons which have been referred to in recent descriptions of American practice relating to high-duty cast irons.

Removing Stresses.

For the removal of internal stresses the castings are stabilised by treating at a temperature of 600 to 650 deg. C. for periods of from ½ to 2 hrs. The tempering operation in the second heat-treatment above mentioned is equivalent to this stabilising treatment. The effect of this treatment is to remove internal stresses which would produce distortion in the subsequent hardening treatment. In the hardening treatment a slight change in dimensions is sustained by the castings. The magnitude of this can be judged from the fact that a 1-in. dia. round bar increases in diameter by 0.0015 in. after a 90-hrs.' treatment.

In addition to its applications for cylinder liners Nitricastiron has already been applied to a variety of cast-iron valve parts, pump parts and machine-tool parts. It has found applications in the various parts of textile machinery and interesting applications arise in general engineering, toolroom and millwright work for jig parts, gauges, pulleys, wearing collars and bushes, and various valve parts and castings used in the construction of coke-oven handling machinery. In handling machinery of all types there are numerous castings where the high strength and excellent wearing properties of this material should prove invaluable.

The rehardening of nitrarded parts without risk of distortion and scaling is also a facility of great importance, and it is to be anticipated that as the properties of this material become more widely known its uses will extend rapidly.

DISCUSSION.

The discussion was opened by MR. W. J. SCOTT, chairman, who said that it had struck him that from the commercial point of view the trouble taken with the process would make it hardly worth while. Was it not cheaper to use ordinary cast iron and replace it when necessary? Did not the cost of the treatment outweigh any advantages of its long-wearing qualities? He would imagine that the temperature at which the iron was treated was enough in itself to deform the inside machine sizes and he would like to know if that was the case.

Function of Chromium and Aluminium.

MR. DAWSON said some of them were familiar with nitrogen hardening of steel, and it was remarkable how closely the cast-iron variety stood to the steel process. That was not quite usual with many processes. In that case, as Mr. Hurst had pointed out, many of the properties of Nitricastiron were only a little removed from steel. When they considered the complexity of cast iron as compared with steel, that was rather remarkable. Mr. Hurst had mentioned the use of the process in steam-cylinder work largely, and it would be interesting to know how the material on the surface compares with the changed surface of the cylinder. After the cylinder had been working for some time the surface and immediately under the surface took on various changes in formation which rendered it less liable to wear, etc. That formation, owing to its resistance to wear, might approximate to the formation under the "nitri" process, but not so harsh, of course. Mr. Hurst mentioned the question of growth, and Mr. Scott had also really mentioned that in relation to distortion. It was remarkable that the amount of growth was so small. He was not quite clear whether the scale or peculiar surface effect that was mentioned by Mr. Hurst earlier on had to be removed after the process in the case of castings where it is stated that they have to be finished machined. If they had to go through the process in a finished machined condition, the removal of the skin or scale would upset the measurements.

It would also be interesting to know the function which the chromium and aluminium played in the alloy itself, and the effect either in themselves or on the formation of the cast iron which was to be treated. He had noticed that the chromium carbides were not greatly affected by the treatment. If that was the case, what other function did they perform? The aluminium might produce sounder castings, but whether it played any part in producing the structure particularly susceptible to the process he would like Mr. Hurst to tell them. With regard to the accurate finish which was required in certain cases, such as piston rings which were tested for accuracy after machining by a light test in a darkened chamber, a much finer test than any hitherto employed, would they be able to obtain that accuracy with Nitricastiron? The treatment itself, which was in principle something

* A Paper read before the Newcastle Branch of the Institute of British Foundrymen, Mr. W. J. Scott presiding.

like applying case-hardening of gases under pressure and time control to cast iron, but with the use of ammonia instead of carbon gases. There was a particular process in being at the present where petrol gas was produced by blowing fine oil on to red-hot cast iron, and the originators stated that in that process some of the iron was absorbed and was found in the resulting gas, or type of petrol as it were. The iron definitely disappeared after a time, and the gas could be tested and found to contain iron in some form or other. In the case of case-hardening by gases it was very difficult to determine whether the same thing took place. He wondered whether Mr. Hurst had observed anything of that nature in the specimens treated by the "nitri" process.

Factor of Comfort.

MR. HURST, in reply, said that Mr. Scott had introduced the commercial aspect of the Nitricastiron. All that he could say was that from his knowledge of history and his own experience in his short lifetime it had been impossible to stop development. It went on in spite of everything, and if Nitricastiron was to be regarded as a development, and if it filled needs which arose from time to time, it would undoubtedly establish itself in the repertoire of alloy cast irons available to the iron founder. There was one aspect of the replacement value of hardened materials, particularly on motor-cars, to which he would draw their attention, and that was that the resistance to wear in parts of a motor-car was not necessary so much to prolong the life of the vehicle, but to prolong the comfort of the vehicle. If wear were to stop on all parts of a motor-car, at the end of three or four years it would sound, when being driven, just like a Rolls-Royce during the first month of its life. Actually, the life of vehicles and of any piece of apparatus was governed by matters other than its intrinsic component parts. Engineering appliances were governed in very much the same way as ladies' dress, by taste and fashion. He had not quite understood Mr. Scott's reference to distortion in hardening. Distortion, of course, was a matter of degree, and whether it was serious or not depended on the degree of accuracy which was required. It was possible to produce, and, in fact, they were producing, cylinder liners guaranteed to plus or minus half a thousandth in diameter without any trouble whatever. If a degree of accuracy of that order was necessary, they would realise that all the parts must be very fully stabilised before the treatment, and in that case distortion would be non-existent.

Instability for Piston Rings.

With reference to Mr. Dawson's very kind remarks, he had asked whether there was any change in nitrogen-hardened surface of cast iron after working in the engine. He presumed Mr. Dawson had had in mind whether the surface underwent any work-hardening effect. He was afraid that he could not really answer that question with any degree of accuracy, as he had not made any experiments to determine whether such effects were present, but he would imagine, in view of the properties of Nitricastiron, that the degree of work-hardening effect would be practically negligible. He had not been quite clear again about Mr. Dawson's question with reference to the removal of scale. Going on to his question as to the influence of chromium and aluminium in promoting a hardening effect, he would refer him to Dr. Fry's Paper before the Iron and Steel Institute last May. Mr. Dawson had asked whether the nitrogen-hardening process could be applied to the production of piston rings. He would be very interested to know that they had made quite a number of piston rings which had passed the light test he had mentioned. That was an additional answer to Mr. Scott, as it showed the degree of accuracy which could be obtained.

Not a Heat-Resisting Iron.

MR. LAMBERT said that he would like to know whether the aluminium and chromium in cast iron and steel were essential for the production of hardness or whether they merely increased the hardness. He would also like to know how the scaling at high temperatures compared with that of ordinary good heat-resisting cast iron.

In reply, MR. HURST said that without aluminium and chromium there would be no hardening effect whatever in ordinary cast irons. With regard to scaling under heat conditions, he was afraid that he had no information as yet as to the behaviour of Nitricastiron under heat-resisting conditions. They did not put it forward as a heat-resisting cast iron.

Machining Speeds.

MR. PAULIN said that the iron which Mr. Hurst had put before them was very interesting to him as an engineer as a problem which he might have to face, but he could see from what Mr. Hurst had told them that its application for long enough would be confined to special work owing to the difficulty of producing the castings cheaply. Mr. Hurst had mentioned that the material was machinable before it was subjected to the process, but, of course, it could not be easily machinable. Did they require special tools? After cylinder liners had been treated, was there no alteration whatever, or did they have to be ground after treatment to ensure perfect fit, and were they again ground after they were in position? Mr. Hurst had referred to the well-known difficulty ensuing from the use of aluminium in castings. That was a thing he had not heard of before. Of course, he had seen founders using aluminium as a cleanser and claiming that it freed the molten iron from gases. He could not say that he had seen any benefit from its use himself, although in that case the amount of aluminium used would be considerably less than the figure mentioned by Mr. Hurst. The effect on the modulus was very important, but it appeared to have a considerable amount of resilience that, when subject to pressure, it did not show any permanent effect such as could be seen on liners when they had been thrust into the chambers, when a definite contraction took place. Did he really mean that, when thrusting liners into a chamber composed of several bars, there was no contraction in the diameter in the neighbourhood of the bars as compared with the space between the bars? That would have a definite effect on the tightness of any valve working in the liner. Although there was a definite claim made that it did not give under load, it was also claimed that it resisted abrasion. To what extent was wear in a motor-car due to ordinary abrasion, and how much was due to road dust drawn in and mingled with the petrol gases? One might almost say that wear was due to a lapping effect of the dust.

No Permanent Contraction.

MR. HURST said that he appreciated very much Mr. Paulin's remarks. Regarding the machinability of Nitricastiron, it was centrifugally cast and machined at 80 ft. per min. The second question raised was with regard to finishing by grinding. They were now finishing nitrogen-hardened liners in position by honing only, and they were removing in that position not more than 2½ thousandth on the diameters. If he had conveyed to Mr. Paulin that Nitricastiron did not undergo any contraction he had done that unintentionally. It would not undergo permanent contraction. If ordinary cast-iron liners were pressed into chambers it would be found that where they came into contact with the ribs there was a bore, and when they were taken out it would be found that they did not spring back to their ordinary dimensions. In the case of Nitricastiron liners there would be a collapse which would be actually 7/20ths of the collapse in the ordinary iron. There would not be so much deformation in the first place, and if the liners were pressed out again they would spring back to almost their original dimensions. That was the difference between the two irons. By reason of that high modulus one had to allow less interference fits on the liners than would be allowed with ordinary cast iron because if the same was allowed the stress would be higher and there would be a risk of breaking the bars. Mr. Paulin's last question really raised the whole problem of cylinder wear with which he did not wish to deal then, but with regard to the proposition that the indrawn dust was absorbed by the soft surface of the aluminium piston and thus formed a lap, consequently producing wear, he would suggest that if Mr. Paulin took the trouble to measure the wear in the cylinder he would find that the maximum wear was at the absolute top of the piston travel when there was no movement at all. Therefore, how it could lap and be still at the same time was very difficult to conceive. The reason why an aluminium piston wore the cylinder more rapidly than a cast-iron one was that a greater clearance had to be left, and therefore the stresses were increased

Road-Dust Theory.

MR. ELSTOW asked Mr. Hurst what amount of interference was allowed on, say, a 4½-in. dia. cylinder liner, about $\frac{3}{16}$ in. thick. He had done tests on the amount of carbon on piston tops for motors and he had found that on an engine without any filter the percentage of silica in the carbon was 47 per cent., which he thought must be due to road dust. He thought the wear curve was more pronounced at one side of the cylinder than the other. He understood that to be due to the direction in which the explosion travelled across the cylinder top. He imagined that that would again bring to bear the hammer theory on the deformation of the top.

MR. HURST replied that the interference fit allowed was intimately connected with the thickness of the liner itself, but for general automobile practice they would allow an interference fit of 2 to 2½ thousandths. They did not rely entirely on the stresses set up for keeping the liners in position, but if one could rely on perfect workmanship it would be sufficient to keep them in position. The liners were either flanged or stepped to guard against any longitudinal movement. He was very interested in the amount of silica found in the carbon deposit on the tops of the pistons in the combustion chamber. He could confirm himself having found silica of the same order, and he entirely agreed that it must be road dust. He was also interested to have Mr. Elstow confirm that the wear was more pronounced in the direction of the explosion.

Increased Pressure and Wear.

MR. PAULIN, jun., said that Mr. Hurst had referred to the absence of distortion when rehardening Nitricastiron. He had also said that it was impossible to soften it and the figures indicated that it was impossible to wear it out. Where did the necessity for rehardening arise? He thought that one reason why there was excessive wear in aluminium pistons was not the fault of the pistons at all. The pressure had increased in cylinders nowadays, and excessive pressure was one of the causes of wear. Another reason was, he thought, that there was greater clearance. The point about the sparking was very interesting because it was another reason for putting the sparking plug in the centre.

In answer to Mr. Paulin, jun., MR. HURST said that if he had conveyed the idea that it was impossible to wear out Nitricastiron it was an incorrect one. It was quite possible to wear it, and he thought it was quite possible also for engineers to overload it at times. With regard to Mr. Paulin's further comments on cylinder wear, he could only say that they were very much in line with his own ideas. It was a fact that the introduction of aluminium pistons had been caused by the desire on the part of the

(*Concluded on page 32.*)

Some Experiences with the Balanced Blast Cupola.

DISCUSSION.

MR. E. W. WYNN, in proposing a vote of thanks, said that as a user of a balanced-blast cupola he could endorse most of the information submitted to the meeting. Although some of his (Mr. Wynn's) figures did not quite agree with Mr. Shepherd's, the discrepancy was probably due to slight differences in practice, and difference in quality. The cupola, of course, was about the most important unit in the foundry, yet in many cases the design had not received the consideration it deserved. With the balanced-blast cupola they could not make that complaint. But no matter how perfect might the units be supplied, disappointment would follow, unless the foundryman was prepared to keep an open mind, and not condemn the plant before he tried it, because his practice had to be varied. They must adapt their practice to suit the cupola. If there were complaints, it was usually because the foundryman had not got down to his job. In the works with which he (Mr. Wynn) was connected they had a rather particular kind of casting to make. They were all pressure castings and Mr. Shepherd had said that he used about 15 to 25 per cent. of steel. During an experiment they had found it quite possible to melt 100 per cent. of steel and pour it in the castings. Although the castings were not machinable, they were cast, and they regularly used 50 per cent. of steel. They did not get any porous castings, nor was refined iron used. They used steel and pig-iron at ordinary pig-iron prices Anyone making pressure castings should get a balanced-blast cupola. He was interested to hear the rather low-blast pressure used by Mr. Shepherd, and he should experiment to see if he could reduce his blast pressure, which was very much higher than Mr. Shepherd's. He (Mr. Wynn) could not quote any figures with regard to coke ratio, but he could say that there was an appreciable saving compared with their previous cupola, while as regarded fluidity and clean metal they certainly got as good metal, and probably better, than many. They had a very small bore cupola and at first they experienced some trouble in lining; but the difficulty had been overcome.

MR. A. J. SHAW, in seconding the motion, said that, unfortunately, he was not a user of a balanced-blast cupola, and, unlike Mr. Wynn, he did get porosity occasionally! Mr. Shepherd had made out a very good case. They had all heard a great deal about the balanced-blast cupola and they had now been given some figures on which they could meditate.

The motion was heartily endorsed by the meeting.

Operating Details.

MR. F. C. EDWARDS asked what Mr. Shepherd meant when he said that they did not stop the cupola for repairs. Was it never repaired?

MR. SHEPHERD explained that when he said the cupolas had to operate every day, it must be remembered that there was also a night, and the cupolas were repaired in the night-time.

MR. G. W. BROWN called attention to the fact that while Mr. Shepherd had given them the pressure, he had not mentioned the volume of the air that he was putting in. He would also like to hear the figures regarding the cost of the daily patching.

MR. SHEPHERD said he did give the figures for cost of daily patching—1s. 3d. to 1s. 4d. per ton of metal melted, labour and material. He could not give figures showing the volume of air entering the cupola. Owing to the ease of control of the cupola they could shut the air down to the amount required to produce good, hot iron, free from oxidation. The proof that there was no excessive air going into the cupola was the absence of ebullition, or sparking, in the ladle.

Oxidised Iron.

Replying to further questions, Mr. Shepherd said that oxidised iron was recognisable by the sparking that took place in the ladle and by the appearance of the chill-piece cast from every ladle. When iron was oxidised the chill-piece had an unmistakable structure. A third test was the appearance of the pouring heads on the castings. As to fluidity, he could only say that the number of short runs was decreased. In the case of malleable iron the metal was tapped in an 800-lb. mixing ladle. From that it was poured into 200-lb. trolley ladles and from various points the men came and drew metal in the ordinary small hand-shanks. It was possible to hold that metal quite a number of minutes over and above the time they were able to hold it previously. He did not agree that by spreading the fusion zone over a greater area it caused trouble. The important consideration was to have an even fusion zone. In operating the malleable cupola he had to deal with silicon contents of 0.7 to 0.8. If they had a lower silicon content they immediately got castings which they could not anneal—he was speaking of black-heart malleable—while if they had the silicon running up to 0.85 or 0.9 the result was primary graphite, which, again, defeated the object. It was important to control the chemical composition of the metal within very fine limits. In his own case they did it by hourly analyses of the metal, and checks on the chills formed out of every ladle. The fact that they kept very close to 0.7 or 0.8 of silicon proved that there was no deteriorating effect on the uniformity of the metal coming from the cupola. They could adjust the metal very quickly if there was any trouble.

MR. F. J. COOK said there was a great deal of interest in the cupola, and the present was the first opportunity they had had of examining the results. As to the shutting-off of the bottom tuyere, probably the reason was to keep the bottom tuyere clear. If the shutting-off of tuyeres saved pokering, and did so effectively, he thought it was an improvement on the usual type of cupola. Many years ago he did some work on blast furnaces and volume, and he then suggested that it would be good practice in cupolas if the tuyeres could be altered at will. He did not pursue the matter further, whereas Mr. Fletcher had brought it to perfection. It was an outstanding feature of his design which had proved to be so good.

Oxygen in Iron.

MR. J. E. FLETCHER said he agreed that it was very difficult to prove whether they had got oxidised iron. Some recent investigators had proved beyond doubt that even in the blast furnace, especially when blowing down for soft irons or high-silicon contents, there was a considerable amount of oxygen in one form or another in the iron. By polishing a section they could see porosities that they had never dreamt of before. The gases that could be pumped out of pig-iron contained CO, CO_2 and hydrogen largely. They would find that oxidation had been taking place in almost any pig-iron they examined. These thoughts were in his mind when he first conceived the idea of the balanced blast cupola. The question had been raised of the advantage or otherwise of three rows of auxiliary tuyeres. He wanted them to understand that it was not guesswork that had led to the putting in of the top row of tuyeres. The tuyeres were made so that they could be adjusted to any area of opening or they could be closed completely. They had found that in certain melting the four rows were necessary. On the other hand, when they wanted to drive the cupola very fast, or get a particularly highly-superheated metal, he very often closed the fourth row. The cupola was very sensitive to valve closing and opening in the bottom row. Mr. Cook had referred to his (Mr. Fletcher's) method of working one dead tuyere. He had purposely designed the cupola so that there was always one tuyere too many. If it was a four-valve cupola, he generally used three live tuyeres and one dead, and they were operated in such a way as to spread the stream across the coke bed without coming across the same diameter at any time. That, he thought, explained the reason for using the odd tuyere. He found generally that what they had been apt to conceive as a thick slag lining was nothing of the kind. When a tuyere looked as though it was blocked up with slag, he had taken a piece of coke out and there was only just a curtain that lay over the slag. Generally speaking, the slag trouble had not been particularly difficult. They were striving in the cupola to get a deep coke bed which was incandescent at a very high temperature. His present aim was so to arrange that temperature that it was not absolutely the same from top to bottom, because they wanted the lower part to superheat the iron. They had to ascertain for themselves what was the proper weight of metal charged that would suit the cupola. They were not likely to get the kind of results obtained by Mr. Shepherd unless they gave some attention to the scientific side of melting practice. Instead of attacking the problem of burning carbon, he had tackled the question from the point of view of burning air. He had worked on the idea that so much air should burn so much coke.

MR. W. MCQUEEN, referring to the closing of one tuyere, said he had used that system for the last twenty years on the old cupolas, and in some parts of the country the practice was quite common.

Elasticity of Operation.

The BRANCH-PRESIDENT (Mr. J. G. Pearce) said the development of the balanced-blast cupola was in line with the rest of the work which the Association was carrying on. The research work undertaken in the past five years had brought home the supreme importance of a high melting temperature for cast iron. It was almost impossible to have too high a temperature in the melting zone where the metal was actually brought down. He wished to point out that they could not get the same ratio on every cupola. The ratio obtainable on a malleable cupola was very much lower than the ratio they could get on a normal grey-iron cupola. A coke ratio of about 5 or 6 to 1 was usual for malleable and he imagined that there were very few people who came anywhere near Mr. Shepherd's figure of 11½ to 1 for cupola malleable melting. Mr. Shepherd was probably doing it more cheaply than anyone else in the country. He knew of only one other case where that figure was approached, namely, a white-heart cupola giving about 11 to 1. He thought they could congratulate Mr. Shepherd and his company on the enterprise they had shown in this connection. It must also be some satisfaction to them to reflect that they were saving each year between 50 and 60 times their annual subscription to the Association! In his view two points about the cupola should be emphasised. First of all, there was tuyere control, which was novel in its manner of application; and, secondly, there was the fuel, which many people were apt to overlook, that the cupola as a whole was a design. The results could not be obtained by applying values to an existing cupola without regard to considerations of the design as a whole. Every bit had been

(*Concluded on page* 30.)

Steel for Steel Castings.*

By W. West (Leyland Motors, Limited).

The real problem of the steel founder is intelligently to anticipate the behaviour of the molten steel after it has been cast in the mould. There are many factors which influence its behaviour when solidifying under these conditions. Primarily, design is of outstanding effect, and in most cases can only be controlled in its action by a limited number of means, such as internal and external chilling, effective disposition of feeding heads of such a size that static pressure

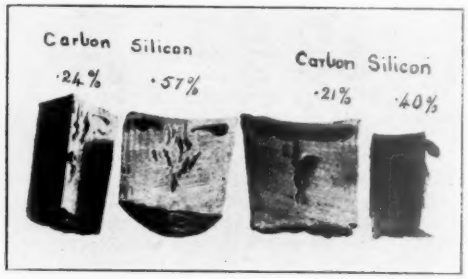


FIG. 1.—FEEDING HEADS OF CASTINGS FROM ORDINARY AND TITANIUM-TREATED STEEL.

of a fluid mass can look after irregularities in cooling rates of differing sections, the manner in which the molten metal is introduced into the mould, and, lastly, the nature of the mould itself. These factors characterise the moulders' "art" and vary from foundry to foundry according to the views of the men concerned and the variety of work being produced.

No attempt, however, will be made in this article to deal with such methods of castings as might be profitably adopted, because the complications which arise in giving anything like

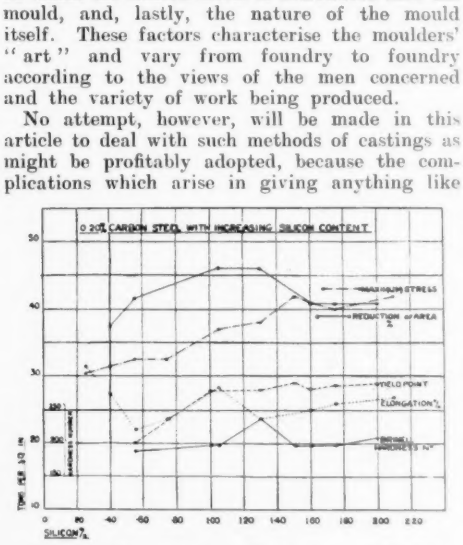


FIG. 2.—INFLUENCE OF SILICON ON 0.20 PER CENT. CARBON STEEL.

a comprehensive review quite naturally limit the consideration of the subject to the production of a few of the many types of castings.

The difference between good and bad castings cannot always be attributed to inefficient or ineffective methods of mould making or running of the castings, but more than likely has its origin in the molten metal. The various methods by which steel is manufactured provides ample proof that all steels of the same composition are not alike in their behaviour during solidification. Acid open-hearth steel is considered to be more reliable for the production of steel castings than open-hearth basic, due to the difficulty in the process of obtaining a true slag-metal equilibrium of the oxides, which provides the ever-present tendency of this latter process to produce blow-holes in the finished product.

* A Paper read before the Sheffield Branch of the Institute of British Foundrymen, Mr. C. D. Pollard presiding.

Turkish Bath Analogy.

The pneumatic process of converting pig-iron to steel has, according to many authorities, the excellent character of producing steel which has the property of lasting longer in a fluid state and so allowing a more perfect feeding from the risers to the castings than the steel produced in the electric furnace, of any type. This difference in the behaviour has been popularly likened to two human beings of similar constitution, both of which have arrived at the same degree of perspiration. One has produced the effect by running a certain distance, and by physical exertion set up reaction within his system which directly produces the temperature increase. The other fellow may sit inactive in a heated room, and, so long as the applied heat is great enough, so can his temperature be raised equivalent to that of his confrère. If both bodies are now exposed to a drop in temperature, it is easy to follow that the second case will feel the change more quickly than the first.

The phenomenon may be explained inasmuch as the first has a greater molecular movement than the second, not totally due to the elevation of temperature within him, but because of the dynamic power imparted to molecules by the character of the "energy expended." The second case, dynamic movement of the molecules within the body is equal only to the heat applied, and so check upon such movement by a quick reduction in temperature has a greater effect than in the other case where movement of the molecules is supported by a latent power of the mechanically-mixed gases.

The great problem of shrinkage of steel is affected by the small, but important, factors, and may be approached from various angles:—(1) the method of treatment of the molten metal during manufacture; (2) the composition of the finished metal, and (3) the design of the casting into which the metal is poured, the shape and disposition of the feeding heads.

Preparation of the Molten Steel.

The manner in which the molten metal is corrected for composition has a direct bearing upon the character of the shrinkage during casting, and the process is divided up into two sections. First, the "boil," during which period the metalloids are removed, and, second, the elimination of active oxides or gases. The regularity of the "boil" is an indication that the metal and the slag which covers it, have correct compositions. In some cases the boil may be difficult to start owing to the slag being richly charged with protoxide of iron, when more often than not the addition of a piece of pig-iron is sufficient to bring the reaction about. Normally the stoppage of the "boil" or its diminution is a warning that the metal and slag are in a state of equilibrium. It should, therefore, be the aim of every careful operator to arrange that in acid-furnace practice there is an almost complete reduction of active protoxide of iron in the slag coincident with the obtaining of the correct percentage of carbon in the bath, together with the attainment of approximately the temperature required for tapping the metal.

In the first place a high-carbon content, at melting, of about 1.0 per cent., is the best provision that can be made for the production of good steel. It means a prolongation of a period which deoxidises the bath, and clarifies the metal of numerous non-metallic inclusions which are otherwise difficult to remove. A "boil" should not be brought about by the application of excessive temperature to the bath, but rather a combination of exothermic chemical reaction supported by furnace temperature. It is in this direction that the pneumatic process has one advantage by producing the necessary temperature for casting from exothermic reactions, and so bringing together into intimate contact the reacting bodies.

A low-carbon content at melting would shorten this important period, and there is every likelihood of undesirable conditions arising such as a combination of low temperature with over-oxidised metal, which must inevitably give bad results though the steel be "doctored." Further, any desire on the part of an operator to accelerate production calls for severe censure. To accomplish this end, a short hot flame in the open-hearth furnace be used, or the high-voltage tappings in the case of an electric

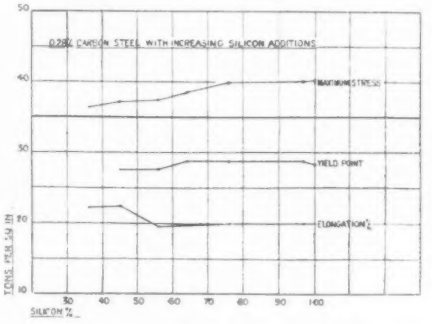


FIG. 3.—INFLUENCE OF SILICON ON 0.28 PER CENT. CARBON STEEL.

furnace, causing the bath of metal to be highly charged with dissolved oxides owing to the temperature of the bath rising quickly. On the other hand, a soft flame in the open-hearth furnace, or low tappings in the electric furnace, will prolong the operation, yet the character of the product will be better than under the first-named condition.

Deoxidation.

The result of chemical reaction between active oxides and the metalloids allows of the metal to absorb gases, some of which escape during solidi-

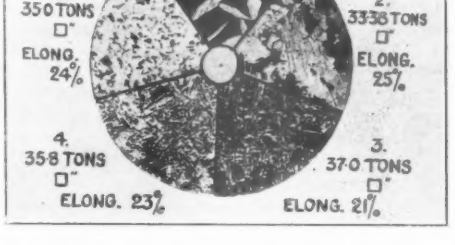


FIG. 4.—MICROSTRUCTURE OF A 0.40 PER CENT. SILICON STEEL.

fication, whilst others are retained during solidification. Of the gases which escape during casting, carbon monoxide forms the main constituent gas, whilst the gases retained by the solidified metal may consist of hydrogen principally. Considering for a moment the gases retained mechanically by the metal—the large proportion of which will be carbon monoxide—these are formed in the interior of the metal itself, under conditions which do not permit of its instantaneous liberation. There must be, therefore, minute bubblets formed which will unite among themselves into large bubbles and thus escape from the metal. In order that this may take place, time must be allowed, and during this period the metal and slag must be retained in

such reactive conditions as to produce a slow, yet effective, boil on the bath. Thus the conditions for the production of a metal with a low gas-content are dictated by the chemical reaction taking place.

This reaction becomes slower and slower with approach to a state of equilibrium, under which the carbon in the bath is almost eliminated, the active oxide both in the slag and the metal are almost spent and the metal itself has had the

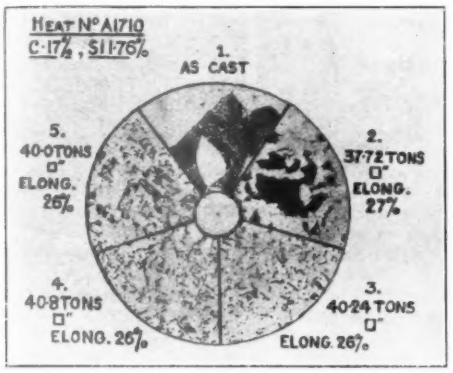


FIG. 5.—MICROSTRUCTURE OF A 1.76 PER CENT. SILICON STEEL.

requisite time to clear itself of a large portion of the mechanically-mixed gas. It is, therefore, of the utmost importance in practice to exercise the greatest care in the amounts of iron ore added to a charge during the boil, so that these conditions can be obtained. Small quantities of 5 to 10 lbs. of iron ore in excess are sufficient to upset a well-balanced phase of slag and metal. In spite of the most painstaking observation of all precautionary measures, which are adopted to prevent an excess of oxygen in the slag, the absorption of gases by the metal cannot be avoided, and almost always the amount of gas is

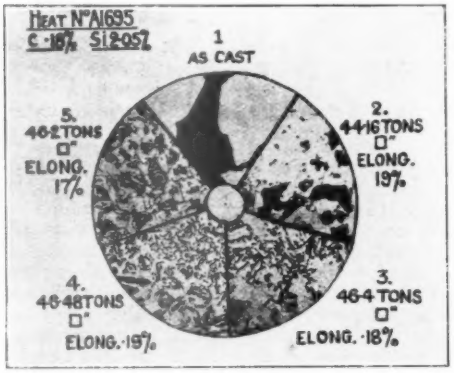


FIG. 6.—MICROSTRUCTURE OF A 2.05 PER CENT. SILICON STEEL.

of such a quantity that a portion thereof must be removed. This is effected by the additions of reducing agents such as manganese, silicon, titanium, etc., to the bath.

Manganese reacts most favourably under the conditions ruling, because of its greater affinity for oxygen. The reaction occurs without evolution of gas, and the resultant manganese protoxide does not markedly impair the quality of the metal if it should not be allowed time to separate, and, therefore, remains in suspension. Ferro-manganese, in which form manganese is usually added, contains carbon, and deoxidation by this means gives rise to a certain degree of gas formation through its reaction with active oxides in the metal. Silicon has a much feebler action as a deoxidiser than manganese, the product of oxidation, "silica," being retained by the metal in a state of fine division. Silicon, like aluminium, possesses a property which manganese does not, by its power to increase the solubility of the metal for gases, and retaining them in this state on solidification.

Titanium in Steel making.

Many claims have been made for titanium as a powerful deoxidiser and cleanser of molten steel, and the degree to which ferro-titanium is now used would appear to justify such of its properties. One firm of repute in America, entirely engaged on the manufacture of highly-refined steel for high-pressure and high-temperature service, advertise their method of manufacturing steel thus:—"Advantage is taken of the high temperature during the refining period to cause certain reactions to take place between the metal and slag and gaseous phases, which liberates certain elements from the slag phase, and, entering the metal phase in a nascent condition, gives certain properties not attained in any other process. The extra degree of purification is obtained through a new and valuable development in the metallurgy of steel by introducing ilmenite ore in the bath during the proper stage of refining."

The physical and chemical properties are given as follow:—

Physical Analysis.—Elastic limit, 21 to 25 tons per sq. in.; ultimate strength, 35 to 40 tons per sq. in.; elongation in 2 in., 28 to 38 per cent., and reduction of area, 35 to 60 per cent.

Chemical Analysis.—Carbon, 0.25 to 0.35; silicon, 0.30 to 0.40; manganese, 0.65 to 0.75; sulphur, under 0.035, and phosphorus, under 0.035 per cent.

This process of refining is unique as on the face of things it is somewhat difficult to understand which is the proper stage of refining, and for what service the ilmenite-ore additions are made to the bath. Ilmenite ore gives the following analysis:—TiO_2, 52.25; SiO_2, 0.27; Fe_2O_3, 42.154; Al_2O_3, 0.29; CaO, traces; MgO, 0.03; P, 0.016; MnO, 5.00 per cent. and Cu, nil.

The composition of this ore rather points to its use as a deoxidiser, provided always that there is some material present at the same time to effect a reduction of the titanium from the titanium oxide. The certain reactions then, as previously mentioned, which take place between the metal and slag and gaseous phases, may be exothermic in character between titanium oxide of the ilmenite ore and the ferro-silicon additions—which would liberate, according to theory, "certain elements," *i.e.*, titanium and iron from the slag phase into the metal phase, and so act as a complete deoxidiser, after which manganese additions are made. Experiments have been carried out to effect a reduction of titanium from ilmenite ore by exothermic reaction of silicon, and some of the results and observations from them are enumerated in this Paper.

The procedure taken was to bring a bath of steel in a basic-lined electric furnace to a state in which the carbon had been reduced from 0.8 to 0.1 per cent after a prolonged boil, and the oxides of iron in the slag as low as possible. No dephosphorising was necessary owing to the quality of the material used, but in order to remove a large proportion of the active oxide material, the slag covering was entirely raked off and a new one formed by the addition of lime and a little fluorspar. A mixture of ilmenite ore and fine ferro-silicon was added to the surface of the slag, in quantities of 20 to 30 lbs., until the whole amount had been transferred to the furnace. The proportions of ilmenite ore and ferro-silicon were varied from time to time until some decision was arrived at. The mixture of the two bodies commences reaction immediately on entering the furnace, when, after simmering for about ½ hr., samples taken from the bath were found to be perfectly "dead." Further additions of ferro-manganese were made in order to make the required composition of the final metal.

Several points of interest have been noted during the carrying out of the experiments, chief of which was that practically all the titanium oxide was found in the slag and only traces in the steel. The metal on being poured from the sample spoon flows quietly with the appearance of oil, and shows no play of escaping gases during casting or setting. It was found, how-

TABLE I.—*Shows the Effect of Silicon Increases with 0.28 per cent. Carbon Nickel Steels—All Results have been Obtained from Annealed Samples at 920 deg. C.*

Heat No.	Chemical analysis. C per cent.	Si per cent.	Mn per cent.	S per cent.	P per cent.	Ni per cent.	Ti per cent.	Mechanical tests. Y.P. tons per sq. in.	M.S. tons per sq. in.	E. on 3 in. per cent.	R. of A. per cent.
A9089	0.27	0.38	0.83	0.010	0.026	0.84	—	—	37.0	23.0	—
A7980	0.28	0.45	0.66	0.010	0.024	0.66	0.010	28.0	37.4	23.0	35.0
A7977	0.28	0.56	0.78	0.018	0.036	0.54	0.014	28.0	38.0	23.0	33.5
A8026	0.30	0.64	0.77	0.024	0.025	0.60	0.028	29.0	39.14	19.0	27.5
A8073	0.30	0.73	0.78	0.024	0.028	0.73	0.020	29.0	39.8	20.0	22.0
A8079	0.26	0.97	0.80	0.018	0.038	0.73	0.020	29.4	39.7	19.0	23.0
A8093	0.27	1.05	0.85	0.040	0.020	0.81	0.032	28.72	40.8	20.0	27.5
A8052	0.31	1.31	0.81	0.018	0.033	0.63	0.036	21.6	43.2	17.0	21.0

0.20 PER CENT. CARBON.

Heat No.	Chemical analysis. C per cent.	Si per cent.	Mn per cent.	S per cent.	P per cent.	Ni per cent.	Mechanical tests. Y.P. tons per sq. in.	M.S. tons per sq. in.	E. on 3 in. per cent.	R. of A. per cent.	Brinell hardness.
A8453	0.20	0.24	0.60	0.024	0.035	0.70	—	30.7	31.0	—	—
A1889	0.19	0.40	0.51	0.018	0.015	0.50	—	31.2	27.0	37.7	—
A705	0.21	0.56	0.64	0.012	0.020	0.67	19.6	33.0	22.0	30.5	187
							20.4	33.2	28.0	42.5	179
A 770	0.21	1.08	0.73	0.028	0.033	1.18	28.8	36.84	29.0	51.0	197
							28.4	36.84	27.0	40.5	197
A 720	0.21	1.28	0.69	0.018	0.023	1.19	29.0	38.30	26.0	48.0	229
							28.0	38.60	25.0	45.0	207
A 718	0.24	1.48	0.61	0.014	0.025	1.11	29.0	42.0	20.0	27.5	197
							30.6	42.0	24.0	36.0	197
A 725	0.22	1.64	0.72	0.016	0.025	0.86	27.9	40.50	25.0	41.5	197
							28.0	40.90	25.0	41.5	187
A 737	0.18	1.74	0.72	0.022	0.024	1.01	27.8	40.0	27.5	47.0	187
							30.4	40.0	25.0	39.5	197
A 734	0.19	2.17	0.70	0.020	0.020	0.99	31.4	42.2	23.0	35.0	217
							30.6	42.4	28.0	47.0	197

XUM

ever, that very little control could be managed over the final amount of silicon in the steel, and this point is a problem which has so far defied solution. One outstanding feature of steel made in this way is the difference in the molten state, it appears to be of a much denser nature, apparently lifeless, yet possessing equally as long a period of fluidity, if not longer, than that of a similar metal in the usual manner. Confirmation of this is to be seen in its behaviour in the feeding heads of a casting. Fig. 1 shows the comparison of two similar steels, one deoxidised in the furnace by additions of 10 per cent. ferro-silicon, followed by ferro-manganese and 50 per cent. ferro-silicon, the other deoxidised by the use of ilmenite ore and ferro-silicon. The latter has not the same degree of suckle as the former and appears to have a general shrinkage than

TABLE II.—*Physical Properties of Titanium-treated Nickel Steels.*

Heat No.	P. tons per sq. in.	M.S. tons per sq. in.	E. on 2 in. per cent.	R. of A. per c nt.	Bend deg. 1 in. × ¾ in.	Izod. Ft.-lbs. 10 mm.	B.H. No. 3,000 kilos.	Heat-treatment.
A1600	23.92	33.36	25	42	180 W.F.	45	143	Heated to 950 deg. C., soaked 2 hrs., cooled in furnace.
	28.6	37.0	21	29	180 W.F.	58	179	Heated to 950 deg. C., soaked hrs.; water quenched. Reheated to 650 deg. C.. air cooled.
	26.0	35.8	23	33	144 F. ..	55	170	Heated to 950 deg. C., soaked 2 hrs.; water quenched, and reheated to 750 deg. C., soaked 2 hrs.; and air cooled
	26.4	35.0	24	33	150 F. ..	56	156	Heated to 950 deg. C., soaked 2 hrs.; water quenched; reheated to 850 deg. C., and air cooled.
A1710	28.0	37.72	27	50	180 W.F.	21	176	Heated to 950 deg. C., soaked 2 hrs., and cooled in furnace.
	31.2	40.24	26	42	180 W.F.	26.8	183	Heated to 950 deg. C., soaked 2 hrs.; water quenched; reheated to 650 deg. C., and air cooled.
	31.6	40.8	26	42	180 W.F.	34	187	Heated to 950 deg. C., soaked 2 hrs.; water quenched; reheated to 750 deg. C., and air cooled.
	31.6	40.8	26	42	180 W.F.	24	187	Heated to 950 deg. C.; soaked 2 hrs.; water quenched; reheated to 850 deg. C., and air cooled.
A1695$_1$	31.4	44.16	19	27.5	62 F. ..	21	207	Heated to 950 deg. C.; soaked 2 hrs.; and cooled in furnace.
	35.6	46.4	18	24.0	74 F. ..	7	229	Heated to 950 deg. C.; soaked 2 hrs.; water quenched; reheated to 650 deg C., and air cooled.
	35.44	46.48	19	24.0	69 F. ..	9	217	Heated to 950 deg. C.; soaked 2 hrs.; watch quenched; reheated to 750 deg. C., and air cooled.
	34.6	46.2	17	21.25	52 F. ..	8	212	Heated to 950 deg. C.; soaked 2 hrs; water quenched; reheated to 850 deg. C., and air cooled.

The composition of heat No. A1600 was C 0.19, Si 0.40, Mn 0.55, S 0.020, P 0.013 and Ni 0.83 per cent.; of heat No. A1710, C 0.17, Si 1.76, Mn 0.68, S 0.018, P 0.015, and Ni 0.75 per cent.; and that of heat No. A1695, C 0.18, Si 2.05, Mn 0.65, S 0.016, P 0.018 and Ni 1.02 per cent.

a definite pipe in the centre, as is usually obtained. This feature has been noted in all the experiments and is more definitely pronounced in the round type of head as distinct from the rectangular shape.

The Composition of the Finished Metal.

The variation of the carbon content which is commercially desired in ordinary carbon-steel castings, has little effect upon the shrinkage, except where it is reduced below the figure of 0.2 per cent., when the increase in the degree of suckle is very pronounced, and even more so as the steel approaches 0.1 per cent. Hadfield (J.I.S. Inst., 1889, Vol. 2, page 222) gives a comprehensive review of the effect of silicon and manganese upon alloys of iron in the cast and forged state. Referring to silicon and its action he reports that increasing amounts of this metal causes the samples to be very free from honeycomb, but this soundness in the cast state is only acquired at the expense of toughness or ductility. Further, it is stated that silicon-steel pipes or settles to a much greater extent than ordinary steel, and this in itself is a considerable disadvantage.

Other workers such as Turner (J.I.S. Inst., 1888, Pt. 2, page 302); Paghante (Met. Italiana, 1912, page 231); Bissett, "Iron Age," 1914, page 86; Pomp (Mitt Kaiser Wilhelm Inst. fur Einenforschungen), 1925, No. 58, Pt. 9, page 105, describe the properties of steels having compositions of silicon up to 1 per cent. but none of these refers to any shrinking characteristics, being more taken up with the enhanced physical properties to be obtained therefrom. All these workers have been concerned with the ingot form of casting.

From the experiments carried out using ilmenite ore in the process of refining, results have been picked out where the silicon contents increase in gradual stages from 0.4 per cent. to 2.0 per cent. They are formulated in two series in Table I and Figs. 2 and 3, having (1) with carbon content constant at 0.2 per cent., and (2) with carbon content at 0.28 per cent. In both sets of experiments it will be noted that nickel ranges on the average at 0.8 per cent., and this element and its influence should be borne in mind when considering the physical properties of the various alloys.

Concerning the degree of shrinkage in the feeder heads of castings, all of which were of the same type and cast from every cast, no pronounced increase in this effect was noted. The riser heads after being cut off by oxy-acetylene flame were sectioned, and the peculiar type of sink effect was noticed as the foregoing illustration has shown of one example. Some consideration given to the results of the physical properties of these steels establishes the fact that with low-carbon contents higher tonnage for ultimate strength and yield point can be obtained by an increase of the silicon content. Ductility results are superior to those obtained by the use of the higher carbon, which is usually necessary to produce similar tensile-strength figures.

Metallographic Investigations.

Metallographic investigation of these silicon steels shows a greatly enlarged grain size in the higher-percentage alloys, while the lower contents have a dendritic primary texture, these observations refer to the annealed state, a contrast betwen three of the specimens can be had from the sectional micro-photographs as shown in Figs. 4, 5 and 6. The more vicious character of these steels with higher percentages of silicon promotes the retention of non-metallic inclusions, most probably arising from de-oxidation.

Heat-treatment of silicon-alloyed steel, does not follow the usual methods for plain-carbon steels, as the percentage of silicon increased so it was found necessary to raise considerably the temperature of annealing. Up to 1.75 per cent. silicon a temperature of 900 deg. C. was not sufficient satisfactorily to break down the "as-cast" structure, but at 920 deg. C. a refined-grained fracture was obtained, and in each case there was a slight increase in the yield point and maximum strength, without any appreciable depreciation in the elongation value. To determine the effect of quick cooling upon the various samples up to 1.75 per cent. silicon, test-pieces of 0.40 per cent. and 1.75 per cent. were taken, and after annealing at 950 deg. C., heat-treatment was applied by water quenching from that temperature, and reheating in each case to 650 deg., 750 deg., 850 deg. C., with a following treatment of cooling in air.

Results from these experiments (Table II) show that these silicon-alloyed steels are not greatly susceptible to quick cooling from temperatures from which some reaction would have been expected, there is a distinct tendency for the silicon to keep the steels soft and malleable. The micrographs as shown in the sectional photographs (Figs. 4, 5 and 6) present the various silicon-alloy steels with finer-grain size after treatment of water quenching from 950 deg. C., and subsequent reheating to various temperatures, followed by air cooling.

Considering the highest-silicon steel of the series having 2.0 per cent. silicon, a temperature of 1,000 deg. C. was not sufficient to break down the "as-cast" structure, which was composed of very large coarse crystals. The only treatment to which it yielded was to quench from 950 deg. C. in water, this being the lowest temperature to which it yielded to treatment. Reheating of the water-quenched specimens to various lower temperatures followed by air cooling, yielded slightly higher-tensile strength and yield-point figures without any perceptible reduction in elongation, or increase in hardness.

Conclusions.

It is fairly conclusive from the results of these few experiments that there are no remarkable benefits to be derived from the higher additions of silicon to low-carbon steels for steel castings. One feature stands out, that no abnormal shrinkage takes place with steel containing up to 0.75 per cent., the increased viscosity of such steels in no way impairs the feeding property, in fact, it is distinctly noticeable that the steel has a denser appearance in the molten and in the cold, and is not so susceptible to reaction with extraneous gases to cause blow holes, as is the case with the lower-silicon alloyed steels. Beyond 0.75 per cent. silicon, additions of further amounts do not give any outstanding values to steel for steel castings. The increased difficulty of heat-treatment and the brittleness of the unannealed castings owing to the larger crystal-grain size make the chances of failure from brittleness more possible.

Advantages on the foundry side are to be obtained from the use of such steel with silicon up to 0.70 per cent. Its peculiar behaviour after casting gives confidence as to its excellent feeding property, and also to the freeness of the metal from blow holes. Where an increase of tensile strength and yield point is required without sacrifice of ductility, this kind of alloyed steel appears to hold out fair possibilities. Whether these properties can be obtained from steel with silicon added without nickel or without the presence of ilmenite ore is yet to be proved.

Some Aspects of Selection of Engineering Materials.

DISCUSSION BY PROMINENT METALLURGISTS.

Soundness of Primary Importance.

MR. C. H. KAIN said that after listening to the author's interesting Paper he was reminded of the opening chapter of one of Einstein's books on "Relativity," in which he referred to conscientious teachers chasing reluctant pupils up and down the magnificent staircase of Euclidean geometry; as a founder and metallurgist he now had visions of chasing orders up and down the gigantic staircase of engineers' requirements. It was pleasing to see that the author looked kindly upon the microscope because, as the author knew, that was one of the things which certain sections of the foundry industry, and the malleable industry in particular, were very strongly advocating. It had met with a considerable amount of opposition, but if the pioneers could get the engineers on their side then undoubtedly founders as a whole would follow on and more rapid progress would be made. There was very little in the Paper upon which questions could be asked, but there was one aspect of the foundry and its work which should have been mentioned, viz., the possibility of obtaining sound materials. For a long time he had contended that it would pay engineers when calling for materials for special use to specify a material which could readily be cast or forged into a perfectly sound part in preference to a material which might have higher mechanical or physical properties, but which was more difficult to obtain in a perfectly sound homogeneous form and which, particularly in the case of high-duty material, is very difficult to cast. A great deal had been heard recently about high-duty cast irons. These were very useful, and good results could be obtained with them, but they were very much more difficult to handle than ordinary cast iron. Foundry technique had to be greatly altered to deal with them, but that was a fact which was not fully realised among ordinary ironfounders who tried to deal with them as they did with ordinary cast irons. The result was that these high-duty irons sometimes failed in service, and users consequently complained that these irons were not so good as the irons made by our forefathers.

Reference was made in the Paper to the effect of titanium and molybdenum in cast iron, and it would be interesting to know if the author had any data from his own personal experience, because a great deal was heard about expensive alloys, other than the well-known ones using nickel and chromium. But he personally was inclined to think that equally good properties can be obtained by a careful balance of the ordinary constituents as can be obtained with some special alloys. He was convinced that equally good results can be obtained by a proper balance of the ordinary constituents, such as silicon and carbon, as with some of the special irons suggested in foreign papers using ordinary cast iron with alloy additions. He concluded by thanking the author for an interesting Paper and for making it clear that the engineer is really making a serious effort to understand the materials he is using.

Acceptance on Performance Tests.

DR. H. J. GOUGH (National Physical Laboratory) said the Paper was one which they would all like to take home and study carefully, because it contained a great deal of food for thought. The author had spoken of the restricted intrinsic value of the usual acceptance tests. He himself had given a lecture to the Institute of Metals on this subject some time ago, and he agreed that the tests carried out in an ordinary engineering laboratory or a works laboratory were intended to secure uniformity of material rather than to bring out certain properties of the materials which were required in service. As the result of experience it was known that if certain simple tests were carried out the same material should be obtained which had previously been found suitable for service requirements, and in that way material was automatically checked as regards its properties. He was glad the author had agreed with that point of view, because he himself had been rather criticised and misunderstood at the time he had put it forward; he was still entirely unrepentant.

True Cohesive Force.

A point of very great interest had been raised when the author mentioned true cohesive force. A tremendous amount of ink had been spilled on the true cohesive force of materials by various physicists who worked out the strength of materials from theoretical ideas. They took two atoms and tried to find the force between them and then the force necessary to break them apart; in that way these physicists claimed to get a measure of the strengths developed in service. Personally, he believed it was quite possible that this method was not applicable, because with a material in service or under an ordinary test the first method of failure was by slipping, as the author had said, but that was not necessarily a mechanism of direct rupture. It was a failure under shear, and no mathematician had yet determined the true resistance of any atomic structure to shear. The cohesive forces that had been worked out by many people applied to entirely different conditions. Some of them might remember the experiment of Joffé with spheres of rock salt crystals. The tests were arranged under such conditions that the stresses suddenly introduced into these materials were entirely tensile stresses, but none of the spheres was broken. Those experiments were made with the primary idea of showing that failure in an ordinary test is due to the presence of surface flaws, but the important point is that very high stresses were found to be insufficient to rupture the cohesive forces. What was badly needed at the present time was a mathematical treatment of the cohesive resistance to shearing forces. He hoped and believed that this work would be done some day by somebody, and then our present ideas of true cohesive forces of materials might have to be very drastically revised.

Izod not a Shock Test.

When the author was speaking of the Izod test he had been very interested to hear the definite statement that the Izod test was not a shock test. He knew what the author had in mind, but he wondered if he were right. Stanton and Bairstow some years ago suggested that nothing was disclosed by notched bar impact test which could not be equally revealed by a slow bending test on a notched specimen; that work was not carried sufficiently far, however, to show definitely whether the Izod test is really independent of shock loading. This point is interesting at the present time in view of the recent introduction of a machine which made static bend tests on notched-bar specimens. If the author had gone any farther with Stanton and Bairstow's work and could show that the Izod test was not necessarily a shock test, it would be very interesting and valuable work.

There was another very important thing that the author had overlooked when he mentioned the value of elongation. He said people asked for this test, but did not know why, but that was not quite the case. Ductility has enormous advantages in affecting stress redistribution. There were many examples in this connection. If one took an ordinary beam of, say, wrought iron or low carbon steel having a tensile strength of about 24 to 28 tons, it was possible to apply safely to that beam loads which would produce stresses very greatly exceeding the ultimate strength of the material, if one assumed that the beam remained elastic: the beam does not remain elastic, but neither does it break. The reason was not, of course, that the elastic theory was wrong, but that the ductility of the material enabled a redistribution of stress to take place in the beam section; that was one of the real reasons why engineers attached such great value to the property of ductility, although perhaps it was a point that did not occur to metallurgists.

Abuse of Stanton Test.

Reference had been made by the author to the Stanton repeated bending test. There was probably no greater misapprehension on the subject of testing engineering materials than was the case with the Stanton test. Stanton never intended the test to be used so that materials should be submitted to a certain specified number of drops, and compared on their relative endurances. Stanton made the conclusion—as stated by Mr. Hunt—that by carrying on this test for a very great number of loadings, a resistance value proportional to the fatigue limit would be obtained. With a few drops only a value proportionate to single blow notched-bar value was obtained. Stanton certainly never intended this test to be used in which it is often employed, and much misapprehension exists on this point, especially in American publications.

Reference was made to the factor of safety by the author as covering stress-concentration effects only. It was quite true that the factor of safety was intended to cover such stress concentrations, but from the design point of view it is also intended to allow for such overloads in service that would not be catered for when the job is in the drawing board stage.

It had been very pleasing to hear what the author had said with regard to the work that had been done at the N.P.L. in order to ascertain the cause of fatigue. The work on a single crystal was linking up very well with work on aggregates, but he must give a warning. He did not think it would ever be possible to express the fatigue strength of a given material and a known composition in a formula. He was quite certain on that point, as fatigue was a local occurrence.

Microscopic Acceptance Tests.

CAPTAIN J. CARTLAND said it was pleasing to him that the author had gone back fundamentally to the equilibrium diagram as being the start of all things and the real start for an understanding of the alloy even though the alloy was not to be used in equilibrium conditions. In practice, however, one was immediately up against a difficulty over that because the alloys most frequently used were ternary or, in many cases, quaternary. If we started with an equilibrium diagram for such a material as the so-called manganese bronzes there was a difficulty with regard to the microstructure, and although that was one of the things that it would be useful to have in a specification in future, it was rather difficult to devise a means of specifying the micro-structure. Had the author any views as to how that could be done?

One practical question was with regard to ductility or elongation. Only that day he had been studying the properties of a material which had an elongation under ordinary tensile testing conditions of practically nil. There were, in fact, two materials, and the elongation in both cases was practically nil, but they had very

XUM

different ductilities. What had been done in that case was to machine pieces 4 in. long and ¼ in. square and twist them in grips until fracture occurred and measure the angle of twist. Although in the matter of elongation there was no difference, the angle of twist in one case was 700 deg. and in the other it was about 200 deg., which indicated a vast difference in the material. Therefore, he would be glad to know if the author had any standard method for measuring the difference between the ductilities when they were exceedingly low.

Foundry Co-operation.

MR. S. L. ARCHBUTT, on behalf of the London Section of the Institute of Metals, expressed appreciation of the very warm welcome given to them and also for the hospitality that had been extended to them during the evening. As he understood it, broadly, the function of the chemist was to control the composition of the materials that were being used, and the metallurgist—and particularly the physical metallurgist—to assist in production and to give information as to the effects of variation in composition, heat treatment, etc. But where would the engineer be without skill and experience of the foundryman to translate the results of the work of the chemist and the metallurgist into practice in the form of sound castings and ingots? It was evident that they must all co-operate together. Where functions of the foundryman end and those of the metallurgist begin was, perhaps, a little difficult to say, but obviously there must be close co-operation, and that was recognised in the holding of these joint meetings every year. In thanking the London Branch of the Institute of British Foundrymen for their hospitality, he also expressed thanks for the class of Paper that had been listened to, because it was of special interest to metallurgists and the duties he had to perform, a fact which he felt was a compliment to the London Section of the Institute of Metals.

Grain Refinement.

Undoubtedly the Paper was a valuable one, and he had been pleased to hear Dr. Gough express his appreciation of it. He found little to criticise in it. The author had put forward ideals to be aimed at, he had mentioned the ideal specification, and had pointed out how more fundamental information was required regarding the behaviour of materials in service in order that their physical properties could be evaluated more accurately. There were one of two small points he might raise. One was related to grain refinement. The author had drawn attention to "modification" of silicon aluminium alloys as an example of grain refinement, but it was necessary to be a little careful in this connection. The author no doubt implied by grain refinements a reduction in size of the crystal units or grains and not the structure within it, whereas modification concerned the structure within the grain. Thus it was possible to have quite a coarse grain size in a modified alloy with a very fine micro-structure within the grains. He could understand that the result of modification would be to facilitate slip within the grains.

Regarding the diagram shown at the end of the Paper, he could not quite agree with the author that the presence of a second phase in aluminium alloys necessarily gave a brittle alloy. The author had explained, of course, that the diagram was a very rough one, but we must not forget aluminium bronze, which was duplex in structure but not brittle.

THE AUTHOR: That is a copper base.

MR. ARCHBUTT agreed, and added that perhaps he had misunderstood the author on this point. Regarding magnesium alloys, it was quite possible for dispersion hardening to be used without causing brittleness.

Continuing, Mr. Archbutt commented on Captain Cartland's remarks regarding equilibrium diagrams of complicated alloys, and pointed out that in many cases the amounts of several of the constituents were relatively small, and did not radically affect the constitution of what might be called the basis alloy. For instance, in special brasses the constitutional diagram was essentially that of the copper-zinc basis alloy with phase boundaries modified by the partial replacements of zinc by iron, nickel, tin, etc.

Creep Values.

MR. MURPHY said there was one aspect of his subject which no doubt the author did not discuss for want of time, namely, the behaviour of materials at high temperature. It would be interesting to know the property which the author thought was most important to take into account with, say, an aluminium-alloy piston. From the nature of the problem, involving repetitions and reversals of stress, one would look to the fatigue properties, and obviously the fatigue strength at the working temperature. On the other hand, it was known that under static loading at high temperatures the creep strength was of first-rate importance. Did the author consider that the creep strength should be taken into account in pistons operating in internal combustion engines, or ought one to imagine that when reversing stresses were fluctuating about a mean value of zero, that was not involved? The view had been expressed by people who had given a great deal of thought to this question that the creep value could be ignored under conditions where the reversed stresses were fluctuating about zero. As soon as one began to discuss temperature effects in the automobile engine one came up against many other problems, such as the performance of bearing metals at elevated temperatures, the stability of cast-iron parts, cylinder blocks, cylinder heads and so on, but all this opened too wide a field for discussion at that late hour. A minor point requiring correction occurred in one of the tables where the author in comparing the fundamental properties of metals gave the coefficient of thermal expansion of iron as 6×10^{-6} per deg. C., whereas it should be something like 11 or 12×10^{-6}. However, that was not important, because the author did not deduce anything from that value. Finally, the author's schematic diagram might be read to imply that aluminium alloys containing a second constituent were not the strongest. Probably that was not what the author had in mind, because, of course, the aluminium alloys of highest strength were distinctly complex in structure.

Metallic Inclusions.

MR. CURZON asked the author as to whether he drew the line in the matter of metallic inclusions, both as to size, quantity and distribution?

CAPTAIN CARTLAND said he did not think the difficulty of the equilibrium could be overcome by saying that the quantity of the constituents was very small, because, although they were small in quantity and in proportion, their solid solubility was also small, and that vastly modified the properties of the metal, otherwise these constituents would not be added.

The CHAIRMAN (Mr. H. G. Summerfield) said that mention had been made by the author of experimental values and service values. Obviously they were terms with which everybody was familiar. The metallurgist would often speak of experimental values and the engineer would speak of service values. The foundryman, however, would speak of both, but so far nobody seemed to have given a ratio between the two. He imagined it could only be explained by saying that the service value was the experimental value plus a factor of safety. If the ratio between the two could be reduced to figures or terms which were understandable to the engineer and the foundryman, it would be of great value. It was no use simply saying "Here is the experimental value and here is the service value." We wanted someone to bridge them and give a ratio between them, and then we should know what to ask for in order to get the service value.

Author's Reply.

The AUTHOR, replying to the discussion, expressed his satisfaction that Mr. Kain shared his views concerning the microscope. As to soundness, mentioned by Mr. Kain, this had been left out of the Paper because in a modern engineering works the responsibility for soundness was a function of the inspection department. The question of choosing an alloy that would give sound castings, however, was the concern of the metallurgist, naturally, and it was one of the things to be taken into consideration in what he had referred to rather facetiously as "gentlemen's agreements." On the question of titanium and molybdenum in cast iron, a great deal had been written. His firm had used small quantities of titanium in high-duty irons, which gave a very fine grain. On the other hand, ordinary irons or nickel-chrome irons were obtained which by a proper adjustment of silicon content gave an equally fine structure.

Factors of Safety Abused.

The very interesting remarks by Dr. Gough were almost entirely in agreement with the Paper. In reference to Dr. Gough's suggestion that many people were on the wrong track in measuring cohesive forces, he himself had been rather careful in the Paper to mention that cohesion was reflected by the modulus and thermal properties. He did not suggest that the cohesion was in any way the same thing as the modulus or the melting point or the coefficient of expansion, but there was definitely some relation in the background which was not yet known between the ultimate cohesion between two atoms of a metal and the modulus and the thermal properties. With regard to the Stanton impact test, of course, he had been going purely on Stanton's own work, and no other work had been carried out since, so far as he was aware, on that test. Dr. Gough had rather challenged the point about factors of safety being allowances for stress concentration effects. Of course, these were also there to withstand overloads, as was only too well known, and this reminded him of a man who came to the Vauxhall works the other day in a Bedford 2-ton truck. As a matter of fact he was towed in, and he demanded a new engine. The bearings had run and the whole thing had seized right up and the man was very annoyed about it. When, however, the service engineer took the matter in hand and put the truck on to a weighbridge it was found that this 2-ton truck was loaded to 6 tons 11 cwts., and that, of course, was one reason for factors of safety! It was very interesting to hear that work was progressing at the N.P.L. on aggregates, and he was also pleased, he feared, to find that Dr. Gough had no hope of evolving a formula for the fatigue value of a metal. As a matter of fact, he did not think anybody would, and any question of arithmetical juggling was useless, in his opinion.

It was quite true, as Capt. Cartland had said, that the equilibrium diagrams were very complex for certain types of alloy. For instance, he would not like to go into the equilibrium diagram of a Rolls-Royce alloy, but, as Mr. Archbutt had said, the diagram for manganese bronze was essentially that of an ordinary bronze with the manganese, iron and aluminium in solid solution in the copper, as a rule. Capt. Cartland had also said that the issue could not be avoided by saying that the amount of the added elements was small because their solid solubility was small and they had a vast effect on the properties. That fact was, of course, more or less mysterious because the mechanism was not known, and when it was known we should probably make considerable advance in that direction.

(To be concluded.)

New Demands on the Brass Foundry.*

By J. Arnott, F.I.C.

At the outset it should be understood that the author is not advocating the use of alloys other than gunmetal where the latter is quite satisfactory. Mere novelty is no reason for change, and change is not always progress. In the foundry trade changes are generally forced by the requirements of customers more than by improvements and advances on the part of suppliers. Any proposed increase in the number of alloys to be handled in a foundry should be considered very carefully. There is little or no justification for retaining several alloys of the same type with variations of perhaps only 1 per cent. in composition. On the other hand, various alloys, some of which will be mentioned, have been introduced from time to time to give longer and more satisfactory service for special duties. If certain components were made in ordinary gunmetal, the units of which they are a part, would either not function at all, would have a shorter life, or would require to be larger and heavier.

Gunmetal or bronze is still the main casting alloy of brass foundries, and it has much to recommend it for general use. Its general foundry qualities are good, the melting is straightforward, the shrinkage is not high, and the properties are not much affected by slight alterations in composition. It has moderate strength and good ductility, and in addition there are literally centuries of experience behind its use. At the same time, it is distinctly susceptible to pouring temperature and to the influence of the atmosphere in which it is melted. Too high a pouring temperature, too long time in the molten condition, or too large a percentage of remelt frequently result in porosity on water test. In very bad cases the porosity can be seen on a machined surface. The tests specified by the Admiralty are flattering to gunmetal, and a figure of 14 tons per sq. in. is quite high enough for use in designing.

Hardness.

In many reciprocating and rotary-pumps, air-compressors, control-valves, etc., there are parts which are subject to heavy abrasion and erosion and which call for some non-ferrous metal more durable than gunmetal. In the choice of materials for this type of duty, the Brinell hardness is found to be a very good guide. The results of many years of experimental work on a friction testing-machine, verified by service experience, indicate that in any one type of alloy the greater the hardness as measured by Brinell the better the resistance to wear. In the bronze series, *i.e.*, alloys of copper and tin, the hardness can be increased a little by increase of the tin content, but only a little, since brittleness soon sets in. Starting with ordinary gunmetal at 70 to 80 Brinell, it is not possible to go much above 100 Brinell in a sand casting without completely losing ductility and machinability.

TABLE I.—*Brinell Hardness of Nickel Bronzes.*

Nickel.	Tin.	Brinell Hardness.
Per cent.	Per cent.	
0	10	About 80
10	10	,, 140
15	10	,, 180
20	10	,, 220

Nickel Bronzes.

Here nickel comes to the founder's aid as a means of increasing the hardness. As far as the author is aware, a full exploration of the properties of the useful portions of the copper-nickel-tin series has not yet been published. A few figures, therefore (Table I), will suffice to indicate the possibilities of this range of alloys.

The addition of silicon to these nickel bronzes increases the hardness still further, and over 300 Brinell can be readily obtained. Admittedly alloys of this degree of hardness have not much ductility, but this is not a serious matter since this extreme hardness is desired for parts such as valve seats, liners, thrust rings, etc., which are well supported. The alloys of low nickel content are not troublesome to make since they respond to the general procedure for gunmetal. At higher nickel contents, say 30 per cent. and over, the treatment as regards melting and de-oxidation tends to follow that of nickel alloys. Magnesium is necessary for complete de-oxidation.

The addition of lead to these nickel bronzes carries the same advantages as it does to gunmetal. For parts subjected to very heavy friction, especially with little or no lubrication, the leaded nickel bronzes have excellent properties. They are rather troublesome in the foundry, and it is sometimes a little difficult to obtain clean castings, especially if the percentage of nickel be high. In making up the alloys it is essential to have the melt completely de-oxidised before adding the lead and tin, otherwise a very sluggish metal is produced. Doubtless with experience such little difficulties in technique will be removed. There is no doubt that the range of nickel bronzes is a valuable addition to the materials available for really arduous service.

Increased Strength.

For castings which have to withstand high internal water or air pressures a point is reached where it becomes difficult to meet the conditions with gunmetal. In heavy sections the strength of gunmetal falls to somewhere about 12 tons per sq. in. even if apparently sound and the yield point to a figure of the order of 6 tons per sq. in. For such castings, provided the working temperature is low, the most suitable non-ferrous metal is manganese brass. It can be depended upon to give in heavy castings a tensile strength of at least 30 tons per sq. in., and a yield point of at least 16 tons per sq. in. In view of this, the author has been surprised to see so many heavy hydraulic castings made in gunmetal or phosphor bronze in spite of the difficulties in obtaining completely water-tight castings and preventing distortion under pressure. Yet manganese brass has only had a restricted use. On the surface the reason for this is the apparent difficulty of casting due primarily to the high shrinkage. The linear contraction on a bar ¾ in. sq. 12 in. long is 0.24 in., as compared with 0.16 to 0.17 in. for gunmetal. This high shrinkage must just be compensated for by liberal risers, and since the metal itself is cheap the extra cost of these risers is not serious. The cutting off of risers is frequently a rather expensive business. In this respect foundries as a whole have not taken advantage of the best engineering practice. Modern machine-shops have methods for ripping off metal at high speed, while one seldom sees adequate gear in foundry dressing shops. Manganese brass is not hard on cutting edges. It should be and is possible to cut off risers and feeders cheaply. Modern hack saws with long blades and big gaps in the frame take much of the work, and band saws are also serviceable. Much saving of time could be effected if efficient and quick gear were provided for clamping the work itself, because often the fixing takes longer than the actual cutting.

Manganese brass is not subject to the same type of porosity as gunmetal. With manganese brass any leakage on water test is confined to places where an oxide film has been trapped in pouring. Such defects if present show up at very low pressure and can generally be easily avoided. Castings free from oxide films can be made to withstand water or oil pressures of several thousand lbs. per sq. in.

Strength at High Temperature.

In power production the increasing steam temperatures and pressures impose new demands on the brass foundries. Temperatures of 750 deg. F. (400 deg. C.) are quite common in this country, and a step up to 850 deg. F. (450 deg. C.) in the near future is indicated. Admiralty gunmetal falls away to 6 tons per sq. in. at 400 deg. C., and to 2 tons per sq. in. at 500 deg. C. even for short periods. There seems to be an impression that the mere addition of some nickel confers high temperature strength on any gunmetal. The author has seen several examples of steam valves which failed miserably in service, and which on analysis proved to be a second-rate gunmetal with addition of sufficient nickel to alter their colour.

For high-temperature service it is a case of omission of undesirable elements as well as the addition of suitable ones. Lead is fatal since at temperatures only a little above its melting point (327 deg. C.) it exudes from leaded alloys. The most satisfactory non-ferrous alloys for high temperature steam are in the nickel-copper group. Of these the 70/30 Ni-Cu, Monel ratio is the best known and has had the longest experience in service. The manufacture of Monel castings is attended by certain difficulties. It requires a high temperature for melting, has a high shrinkage, and calls for care in melting and deoxidation. The high temperature required for melting is most easily given by electric furnace or through the use of oil. Even pure nickel can be melted in oil-fired crucible furnaces with low pressure burners and without any pre-heating of the air supply. The electric arc-furnace gives ample heat, but has the drawback that the shallow bath of metal requires more metallurgical attention than the deep charge in a crucible. The high-frequency electric furnace is ideal technically, but its high capital cost puts it outside the scope of most foundries.

The shrinkage of Monel metal is ¼ in. per foot and liberal risers are necessary. These are rather troublesome to remove on account of the toughness of the metal. The Ni-Cu alloys are affected both by oxidising and reducing conditions in melting, and experience is necessary in judging when the metal is in proper condition for pouring. Deoxidation is accomplished by silicon and magnesium or by magnesium alone. Monel metal castings have a strength of fully 25 tons per sq. in. with an elongation of at least 15 per cent., and generally much more. At 750 deg. F. (400 deg. C.) the strength is 20 tons per sq. in., and at 500 deg. C. over 17 tons per sq. in. The hardness of normal Monel is between 100 and 120 Brinell, which is rather too low for certain parts, *e.g.*, of steam valves. The hardness and strength can be increased by the addition of either aluminium or silicon. The silicon-Monel alloy which has been developed in the last few years has not quite the strength of the aluminium alloy, but gives less trouble in the foundry, and has already found certain suitable applications.

In making up, the silicon is added as silicon metal or as high-grade ferro-silicon, the use of an intermediate hardener is unnecessary. The most useful range of silicon is from 2.5 to 3 per cent. At about 2.8 per cent. silicon the metal in the cast state has the following properties:—Yield point, 21 tons per sq. in.; tensile strength, 40 tons per sq. in.; elongation, 20 per cent., and Brinell hardness, 180 points.

Silicon-Monel has the interesting property that it responds to the "precipitation-hardening" type of heat-treatment. When heating to

* A Paper read before the Newcastle Section of the Institute of British Foundrymen, Mr. W. Scott presiding.

XUM

900-1,000 deg. C. and quenched, it is softened to about 140 Brinell, and may be readily machined in this condition. Finally, it is hardened by a simple heating to 600 deg. C. for one to three hours. It then has the following properties:—Yield point, 28 tons per sq. in.; tensile strength, 44 tons per sq. in.; elongation, 20 per cent., and Brinell hardness, 210 to 220 points.

The strength of silicon-Monel at high temperatures is remarkably high, as can be seen from the following tests:—

	Room Temperature.	At 400 deg. C.
Tensile strength ...	45	36 tons per sq. in.
Elongation ...	22	16 per cent.

The impact strength is also well maintained. The following tests are from a series which were slightly lower in tensile strength, viz., 40 tons per sq. in.:—

	Room Temperature.	At 400 deg. C.
Izod	33	26 ft.-lbs.

This heat-treated silicon-Monel appears to represent the best combination of hardness, strength and general corrosion resistance available among non-ferrous casting alloys of reasonable price.

Reduction of Weight.

The post-war Naval programme initiated a campaign for lighter machinery which has had a certain influence on some branches of engineering where the subject of weight had not previously been much considered. The experiences in the use of light alloys could profitably be extended in other directions. There are instances where although the overall weight of a machine may not be a serious consideration, yet it is an advantage to reduce the weight of parts such as inspection doors, covers, etc., which have to be handled frequently. Several years' experience of the aluminium-silicon alloys have served to confirm not only their good properties in the foundry, but also their satisfactory behaviour in service. The latter can be judged from the fact that hundreds of pumps in these alloys are in service handling water and oil at pressures up to 350 lbs. per sq. in. For foundries which have had little or no experience of light alloys on a large scale, the aluminium-silicon alloy is an eminently suitable one. Relatively little alteration in ordinary foundry practice is necessary. The low shrinkage and freedom from hot-shortness of this alloy permit designs made for gunmetal and cast iron to be cast in it.

One important feature is the introduction of chills into the mould and cores in order to improve machinability and increase strength. Flanges and bosses should be chilled by flat plates in the mould, and any extra heavy sections or junctions of walls can be taken care of by chills either in mould or core. Apart from this, the main thing is to ensure that the tenacious film which forms on the molten metal does not become trapped either by stirring or in pouring. The metal should enter the mould without splashing or swirling. As far as the metal itself is concerned, it is found that for castings moulded in sand with a moderately large area of chills the optimum silicon content is between 10 and 11 per cent. With the very pure qualities of aluminium and silicon now on the market, greater ductility is obtainable than at the time when this series of alloys was introduced.

The author had no personal experience of the more recently introduced light casting alloys such as the "R.R." series and the "Birmasil" alloys. From examination of a number of "R.R." alloy castings and from the details of their properties, there is no doubt that they constitute a marked advance in the technique of light alloys.

Copper-Silicon Alloys.

Many people have conferred with the author about these alloys since he mentioned them in a Paper at the Institute of British Foundrymen's Conference last year. As he said at the time, silicon-bronze was introduced as a substitute for gunmetal at a time when tin was dear. It was not put forward on account of any technical advantage over gunmetal. It gave very attractive looking castings with a better skin than would be obtained from gunmetal cast in similar moulds. The one drawback is the high shrinkage. As a result of this, castings of any weight require heavy risers. The cost of putting these on and taking them off, largely neutralises the initial price advantage. At the present time when tin is cheap, there is not a strong case for silicon-bronze. If and when tin again becomes a dear metal, the copper-silicon series will be worth serious consideration for small castings at any rate.

Hardening and Tempering Vanadium Steels.

In a report of the Materials Committee of the Association of German Ironmasters, published in a recent issue of "Archiv für das Eisenhüttenwesen," E. HOUDREMONT, H. BENNEK and H. SCHRADER describe experiments on the influence of the presence of special carbides, in addition to iron carbide, on the hardening and tempering of tungsten steels and especially of vanadium steels. The withdrawal of carbon for the formation of the carbides in question reduces the hardening capacity compared with carbon steels for the same quenching temperature, since most of these special carbides are more sparingly soluble than cementite. Due to the effect of the carbides in retarding crystallisation, the steels are considerably less sensitive to overheating. Since the carbides go more and more into solution with rising temperature, the critical quenching speed is correspondingly reduced, the penetration of the hardening effect being increased. On tempering, the special carbides, which only with difficulty pass into solution at higher temperatures, are only precipitated again out of the α-solid solution at higher temperatures and thereby cause a sort of precipitation hardening. This is superimposed on the reduction of hardness, due to the decomposition of the martensite, and leads to a secondary increase in hardness between 500 and 600 deg. C. This separation of vanadium carbide is the reason for the increased cutting capacity and strength when hot of suitably pretreated vanadium steels. With high-alloy steels, such as high-speed steels, there may accede in addition on the first tempering the increase in hardness due to the transformation of the remaining austenite. The stability on tempering, on the other hand, is solely attributable to precipitation hardening, more essentially in the case of the special carbides.

The effect of vanadium was further investigated in the case of a number of constructional alloy steels. Here, also, it led to great stability on tempering after suitable heat-treatment; at the same time the notch impact value fell proportionately as the result of the precipitation of the vanadium carbide.

Large Electric-Furnace Installation at Sorel, Quebec.—A new electric-steel furnace has been installed recently by Sorel Steel Foundries, Limited, at Sorel, Quebec. The foundry requires approximately 1,000 electric h.p. for its operation, the plant having been built at Montreal by Dominion Engineering Works, Limited. The remainder of the new equipment will not be ready for some time and the new plant is not expected to operate until early next spring. Sorel Steel Foundries, Limited, manufactures manganese, carbon and other steel alloys for mining, quarrying, construction and general industrial use.

Solid-Woven Rubber-Impregnated Belting.

THE "Z" DRESSING PROCESS.

During recent years, considerable progress has been made in the technique and manufacture of transmission belts, and a recent development is the solid-woven belt manufactured under the patented "Z" rubber impregnation process. This new belting combines the advantages of pure rubber as a bonding medium with a solid-woven base.

Briefly, the advantages of this type of belt are as follow:—(1) The compound of solid-woven base and rubber is so flexible that cases are known where ¼-in. thick belts are running satisfactorily over 3-in. dia. pulleys. (2) The old trouble which has been experienced for so long with solid-woven belts of fasteners pulling out is completely surmounted. (3) Even under the worst conditions, where dust is prevalent, and where belts get little attention, the gripping power of "Z" belting is very high. (4) There is no necessity to dress "Z" belts. (5) Oil does not adversely affect the belting; it will run successfully outside under bad conditions, and will drive efficiently when wet.

An endurance and fastener test was carried out on belts running over 16-in. dia. pulleys at a speed of 3,380 ft. per min. At one end fast and loose pulleys were mounted on a shaft which was fastened into a movable carriage sliding on rails, and, therefore, during the test any extension which took place could be measured. The tension on the belts was kept constant by means of dynamometer measurements. In order to destroy the belts as quickly as possible, whilst obtaining accurate results, they were thrown from the loose to the fast pulley 25 times per min., picking up a load of 23 h.p. each time. The joints were made by means of a wire-lacing machine. The initial tension of the slack and tight sides was 640 lbs., and the length of the belts 20 ft. In time the belts failed, usually due to the fasteners pulling out, and the efficiency of the belts was measured by the number of changes from loose to fast pulley they had withstood. Table I gives details of four representative tests.

TABLE I.—*Tests on Belting.*

Type of belt	Width.	No. of complete changes before belt failed.	Temporary stretch percentage.	Permanent stretch percentage.
Rubber and canvas belt, four-ply ..	Ins. 2.25	10,075	4.46	2.31
Red hair belt	2.28	20,069	4.96	2.16
First-grade oak-tanned leather ..	2.25	47,664	6.92	3.17
Patented "Pyramid" "Z" hair belting ..	2.28	84,538	2.10	0.41

Two types of belting are supplied impregnated by the "Z" process, "Swift," an all-cotton belt, suitable for light drives and capable of running around very small pulleys; "Pyramid," a hair belt made from finest hair yarns, which is suitable for all heavy-motor, countershaft, machine and main drives. The patented "Z" dressing process is fully covered by patents in many countries and is manufactured at Hull by Messrs. J. H. Fenner & Company, Limited.

MR. O. C. DINERMAN has been appointed to represent Messrs. Laurence, Scott & Electromotors, Limited, of Norwich and Manchester, for the sale of A.C. and D.C. motors and control gear in Yorkshire. His office is at Standard Buildings, City Square, Leeds.

Oil Engine Foundry Practice.

ELIMINATING VARIABLES IN METAL MELTING.

Mr. H. E. Beardshaw's Paper* gave rise to a typical practical discussion, which is invariably the case from this Branch.

It was opened by MR. WALTER WEST (Preston), who, in proposing that a cordial vote of thanks be accorded to Mr. Beardshaw for his extremely interesting and informative Paper, said that every foundry that made cylinder castings would do well to adopt the system of control outlined by the lecturer. The present question that confronted motor engineers and designers was the matter of excessive weight, and in this direction the possibility of introducing an aluminium frame or skeleton in conjunction with nitrided liners was becoming a very practical proposition. It was as well, however, to keep definitely in mind the differing conditions under which petrol and Diesel-engines operated. On the one hand the Diesel engine did not exceed at the present time 2,000 r.p.m., whilst the petrol engine exceeded 3,000. Because of this there was a greater call upon the cast iron in the petrol engine to stand up against more severe conditions. Mr. West inquired whether the lecturer used to any extent oil-sand cores in the building up of the cylinder moulds, because where oil-sand cores were totally enclosed, or semi-enclosed, or in any part where metal could come into contact, then the factor of the volume of gas evolved from the burning out of the bonding material was one which could not be overlooked when standardising every part of the process. He was of the opinion that in a general way foundrymen did not pay sufficient attention to the drying of cores. There appears to be a diffidence on their part in taking the temperature high enough in order to rid the core of the maximum volume of gas in the drying oven. It was far better to evolve the maximum amount of gas in the oven rather than in the mould.

The lecturer had introduced the subject of refined irons, and Mr. West inquired, from the point of view of information, what refined-irons really were. Solidity in castings had been made more possible by their use, but there was abundant proof that perhaps more than half of refined-irons produced and sold in the market to-day were cupola melted. Mention had been made of silicon in connection with the ultimate composition of the irons used, and it was a matter of interest to the speaker whether the lecturer attached to this element greater importance than to any other in the composition.

So far Mr. West had not found it necessary to use denseners in any shape or form to produce solidity. With reference to the subject of running castings as described by the lecturer, he agreed that it was very desirable in casting cylinders that the metal should be distributed over the mould in order to produce an adequate distribution of heat, but no mention had been made as to how the metal was introduced into the flywheel moulds, and, as the balance of this after machining was of great importance, he would like the lecturer to elaborate this point. It was the practice of the firm with which he was connected to introduce the metal around the inside of a flywheel through an angular ring, with innumerable ingates into the flywheel itself.

MR. S. BROOKES (Heaton Moor) seconded the vote of thanks, which was carried by acclamation.

Gases in Cores.

MR. BEARDSHAW, in responding to the vote of thanks, said that he was extremely interested in regard to the question of liners and nitriding. In dealing with the subject of his Paper, however, he had found it impossible to touch upon every detail. The point concerning oil-sand cores had been dealt with in his previous Paper upon the same subject. Respecting the drying of cores, and the maximum evolution of gas in them, the maximum should be taken to an efficient limit, and not to an extent in which the structure of the core was liable to fail when subjected to the extreme thermal and physical stresses occurring during actual casting. The main feature of refined iron was that there was consistency throughout the cast, which was something never obtainable from a blast furnace. In former times, the objection to analysis was that 20 pigs could be taken and there would be 20 differing results. In the case of refined iron any number of pigs could be taken and the limit of variation throughout a cast would be small. It was the manufacturer who used the term "refined," but the application did not matter as long as the results were consistent. Silicon was certainly the controlling element. As had been stated in the previous Paper, other constituents such as manganese, phosphorus and sulphur were kept within reasonable limits, variations in physical properties being considered according to variations in the silicon content. Silicon was the most certain control which could be adopted in commercial practice. The introduction of material into flywheels had been dealt with also at considerable length in the previous Paper. The material was introduced by runners diametrically opposite and fed to one single bush running across the whole of the box. De-gasifying processes were valuable, for whilst not necessarily carrying out the function indicated by their title, they thoroughly mixed the whole contents of a particular furnace or ladle and effected consistency throughout a particular batch.

MR. WALTER WEST (Preston) thought that the importance of silicon had been somewhat over-stressed.

MR. JACKSON (Accrington) regretted that there were not many foundry owners who would place a moulder upon research work. In the first place, scientific investigation was much too expensive for open competition, and when research work was required, someone was generally brought in from outside the foundry who could tabulate the results obtained, compile indices, etc. It was quite conceivable that the moulder, who was engaged upon certain definite jobs, might feel that such a man was picking his brain.

Are Chills Essential?

MR. E. W. WYNN (Newport, Salop) was rather surprised to hear Mr. Beardshaw say that only refined irons were used in the production of their castings, and that in spite of technical control and metallurgists, they were prepared to pay a high price per ton for pig-iron when suitable metal of regular composition could be obtained from raw material costing approximately half that cost. The statement had also been made that chills were a necessary evil. He disagreed with that remark. For 10 years prior to his joining his present company half of their castings were chilled, and in spite of warning that they had always had to chill their castings and that the same was done in America, he stopped using them, and the resultant castings were much better in every way than those that had been chilled.

In regard to the use of mercury to obtain data for the running of cast iron, he would like to point out that experiments carried out on innoculated iron tended to prove that unless a melting, as distinct from casting temperature, was higher than that obtained in most foundries, the molten cast iron was not a homogeneous liquid. Therefore, as the materials were not comparable, he failed to see how the results could be. He would like to touch upon the point raised respecting the reception of technical men in the foundry. He was quite a young member of the Institute, but he ventured to assert that a man who had not served some time in the foundry was not capable of running it in a business-like way, unless he had the co-operation of very efficient practical men. A laboratory was simply an aid to a foundry, and not the centre from which the foundry could be controlled, therefore it was the man that had both practical and technical knowledge (and could bring this knowledge and experience to solve the problems of every-day production and concentrate the efforts of practical and technical men to obtain the desired end, *i.e.*, good castings) who would make the ideal foundry executive.

MR. BRIERLEY (Denton) thought it was probably correct that some kinds of castings were better without chills, but in other cases they were necessary in order to obtain a casting which was sound. In regard to chills, did Mr. Beardshaw make a point of having the surfaces clean and bright ground? Also, what was his experience as to the best coating for chills.

MR. R. A. MILES (Manchester) considered that the thanks of the Institute were due to Mr. Beardshaw for having taken such minute records of the times spent in drying, pouring and other foundry operations. As he had listened to the particulars tabulated by the lecturer his mind reverted to the time when he was engaged at a certain works when a casting or pattern used to come in having painted upon it "Four gaggers only." He could not credit that any member present at that meeting would have attempted to make it with less than 10 gaggers.

Author's Reply.

The LECTURER, in replying to the discussion, said Mr. Wynn had stated that he had obtained all good castings without chills. He regretted that he could not attain the same degree of perfection. He had found it better to pay the extra cost for irons, the quality of which was assured, rather than to risk the possibility of getting a couple of "wasters" which would run away with the difference in cost per ton, especially if they reached the machine shop and were half-machined before any defect was found. He was afraid he must entirely disagree with the statement that chills were not necessary.

MR. WYNN observed that there was not exactly a difference in opinion between the lecturer and himself. There were special conditions where chills may be a necessity, but many cylinders were made without, and his experience tended to prove that if more thought was given to melting temperature, chills would be reduced to a minimum.

The LECTURER then produced a casting to illustrate his point. The thickness of the bore was approximately $\frac{1}{2}$ in. It was necessary, from a physical point of view, that the thickness should be $\frac{1}{2}$ in., so that, in other words, it was able to carry considerable stresses. In this casting there was a thickness of $\frac{3}{16}$ in. which had to be machined. This set the datum hardness. The $\frac{3}{16}$ in. thickness had to be below 230 Brinell so that it could be machined. The thicker sections were then considerably below 230, how was this to be corrected without densening? It was not possible to obtain maximum machinable hardness without densening, as long as there was a limiting factor that $\frac{3}{16}$ in. must be machinable. The reference to mercury was merely suggestive. By using it he had been enabled to obtain some indication as to the behaviour of molten metals. The coating for denseners must be such as to provide, immediately the iron came in contact with the particular coating, an envelope of gas. Any oily or bituminous matter could be used which would stick and did not collect moisture, but provided an envelope of gas to ease off the initial shock.

* FOUNDRY TRADE JOURNAL, December 29, 1932. Vol. 47, January 5, 1933.

XUM

This Week's News in Brief.

Trade Talk.

THE LOW MOOR IRON COMPANY, LIMITED, have restarted their two blast furnaces.

OWING TO THE recent very heavy increases in the duty on pig-iron by Japan, India has practically lost the Japanese market.

TENDERS ARE BEING INVITED by the Chinese Ministry of Railways for the construction of the Chungshan pier at Hsiakwan, Nanking.

THE CROYDON CABLE WORKS, LIMITED, will on July 3, 1933, repay in cash all the debenture stock outstanding, together with interest and a premium of 5 per cent. on the capital sum.

THE GREAT WESTERN RAILWAY is introducing an improved freight-train service from Birmingham and the surrounding area to Bristol, the West of England, and Plymouth, giving a next-day delivery over this area.

MESSRS. SIR ROBERT MCALPINE & SONS have secured the contract, valued at £200,000, for the construction of a 500-ft. graving dock at Wallsend-on-Tyne for Messrs. Swan, Hunter & Wigham Richardson, Limited.

THE SEITEISUSHO is preparing for the production of 1,200,000 metric tons of steel materials during the next fiscal year, according to our Yokohama correspondent. The programme includes the repairing of some idle furnaces, improvements and extension of a rail mill, the erection of a tinplate mill and other steel mills.

MESSRS. FULLERTON, HODGART & BARCLAY, LIMITED, engineers, of Paisley, who specialise in the manufacture of winding engines, air compressors, hydraulic pumps, etc., have appointed Messrs. E. John Wheen & Company, Limited, of 90, Cannon Street, London, E.C.4, to be their representatives in the South of England.

FULL WORKING TIME for some months is ensured at the Courtybella works of the Whitehead Iron & Steel Company, Limited, Newport. The company have just secured a further order for tube strip from the Soviet Government. All the material will be manufactured at the Courtybella works and shipped direct from Newport to Russia.

EMPLOYEES OF Glasgow and West of Scotland firms have contributed the following sums to charity during 1932:—Drysdale & Company, Limited, Yoker, £175; Fullarton, Hodgart & Barclay, Limited, Paisley, £41; Messrs. Bairds & Dalmellinton, Limited, Lugar, Muirkirk, Prestwick, Kilwinning, Sanquhar and Dunaskin works, £6,694.

THE GREAT WESTERN RAILWAY'S new works programme for 1933 includes 121 engines, 161 coaches, one steamer and two steam hopper barges. In the engineering department 356 miles of permanent way will be relaid and 45 miles of track resleepered or rerailed. This will involve 29,000 tons of new rails, 565,000 sleepers (including 100,000 steel sleepers) and 17,500 tons of chairs, fishplates, etc.

THE 173,231 NEW 6 per cent. cumulative second preference shares of £1 each created at the recent meeting of Messrs. Crompton Parkinson, Limited, are now offered at the price of 22s. a share to the existing 6 per cent. second preference shareholders of the company. The new shares will rank for dividend as from October 1 last and in all other respects *pari passu* with the existing issued 6 per cent. second preference shares.

A NEW ENGINEERING DEVICE which has been designed by the Glasgow firm of engineers, Messrs. James Howden & Company, Limited, in conjunction with Mr. J. Johnson, chief superintendent of Canadian Pacific Steamships, to give increased boiler efficiency, will permit of economies being made in steamship operation. The simplicity of design and low cost of construction make it an important contribution towards the solution of present-day problems of shipowners. The greatest efficiency of air preheating is seldom more than 88 per cent., but with the new device the efficiency is increased to approximately 95 per cent. This is accomplished by washing the gases from the boiler furnace and extracting the heat by the water. A funnel is not necessary for the disposal of the waste gases, which are cool and clean, as they can be discharged through the side of the vessel. Fuel consumption is reduced, weight and bulk of bunkers and machinery are reduced, and cargo capacity increased. The cost will also probably be appreciably less than of the conventional cargo steamer.

Personal.

MR. AND MRS. EDWARD COWAN, of Motherwell, have just celebrated the fiftieth anniversary of their marriage. Mr. Cowan, who has resided for the greater part of his life in Motherwell, was for 46 years employed in the foundry of Brandon Bridge Company, Limited.

MR. R. G. REID, of Stockton-on-Tees, formerly works manager and chief engineer to Messrs. Ashmore, Benson, Pease & Company, Limited, has been appointed general manager of Messrs. H. & T. Danks (Netherton), Limited, boiler makers and engineers, of Netherton, Dudley

MR. AND MRS. WILLIAM BRUCE, of Motherwell, celebrated their golden wedding anniversary on December 29. Mr. Bruce is an ironfounder, and with his sons started an ironfoundry on their own account in Motherwell. Mr. Bruce still takes an active interest in the business.

MR. CORNELIUS CHAMBERS, who was recently knighted, has been chairman of Messrs. Gaskell & Chambers, Limited, brassfounders, etc., of Birmingham, for many years. For some forty years he has been prominently identified with the political, public and social life of the city.

MR. DONALD GUTHRIE, who is on the foundry staff of Messrs. Ashmore, Benson, Pease & Company, Limited, Stockton-on-Tees, after experience as a pupil with the Cast Iron Research Association in Birmingham and Sheffield, has now enrolled as a part-time student at the Ecole Supérieure de Fonderie in Paris.

Wills.

ELMORE, F. E., of Boxmoor, metallurgist	£56,382
COULSON, W. A., of Messrs. Mavor & Coulson, Limited, Glasgow	£25,538
PEACE, J. A., chairman and managing director of Messrs. Cocker Bros., Limited, Sheffield	£13,660
DENISON, G. H., for many years managing director of Messrs. Samuel Denison & Son, Limited, Hunslet Foundry, Leeds	£23,553

Obituary.

MR. EDWARD HEBERLEIN, consulting metallurgist, of 62, New Broad Street, London, E.C., and a director of several copper-mining and other companies, died recently.

MR. GEORGE TAYLOR died at Middlesbrough on December 29. He was 66, and had been connected with the Tees-side iron trade for the past 50 years. Until a few years ago Mr. Taylor held a position with Messrs. William Jacks & Company, but of late had been in business on his own account as a merchant.

WIDESPREAD REGRET was occasioned in the Falkirk and Glasgow districts on Wednesday, January 4, when it became known that Mr. John Mercer, manager of the engineering department of Carron Company, had died very suddenly at his home in Larbert. Mr. Mercer, who was 64 years of age, had been at the works as usual on the previous day, and on returning home appeared to be in his usual health until about nine o'clock, when he complained of feeling ill and retired to bed. A heart attack developed, and he passed away almost at once. He was a native of Carron and had been in the employ of Carron Company for 51 years, the last 26 of which he had been manager of "E" department, and was held in high esteem by the management of the firm. Mr. Mercer was well known in Clydeside engineering circles and was an ex-President of the Glasgow and West of Scotland Association of Foremen Engineers and Draughtsmen. The funeral took place at Larbert Cemetery on January 6, in the presence of a large and representative company which included Mr. George Pate, O.B.E., general manager; Mr. Peter Allan, foreman patternmaker; Mr. C. M. Brown, secretary and voting partner, and Mr. Metcalfe, representing the managerial and office staff of Carron Company; delegations from the Foreman Engineers' and Draughtsmen's Association, local works and other institutions with which the deceased was connected.

Contracts Open.

Belfast, January 20.—Iron and steel stores, for the Town Council. The City Surveyor (Room 83), City Hall.

Belfast, January 24.—Iron and steel stores, for the Corporation Tramways Department. The General Manager, Tramway Office, Sandy Row, Belfast.

Halesworth, January 23.—1,360 yds. of 4-in. British cast-iron spigot and socket pipes, specials, etc., and one multi-stage centrifugal pump, for the Council. Mr. J. H. Matthews, water engineer, Council Offices, Halesworth, Suffolk.

Liverpool, January 19.—Iron and steel stores, for the Corporation. The General Manager, Liverpool Corporation Tramways, 24, Hatton Garden, Liverpool

Market Overton, January 21.—Supply and erection of artesian pump, 5-h.p. Diesel engine, pump-house and 20,000-gall. elevated storage tank, for the Oakham Rural District Council. Mr. M. Mullins, St. Botolph's Road, Sevenoaks, Kent. (Fee £2, returnable.)

Port Talbot, January 16.—600 yds. of 12-in. spun-iron water main, for the Town Council. Borough Surveyor's Office, Municipal Buildings, Aberavon. (Fee £2 2s., returnable.)

Upton-on-Severn, January 24.—Deep well pump at Upton-on-Severn, capable of delivering 4,000 gall. per hr., for the Rural District Council. Mr. J. H. Haiste, Middleton Chambers, Lowgate, Hull. (Fee £3 3s., returnable.)

Company Meeting.

Presiding at the annual meeting of Messrs. Yarrow & Company, Limited, SIR HAROLD E. YARROW, Bt. (the chairman), said that in spite of the continued depression in the shipbuilding and marine engineering industries, the directors were able to recommend a payment of 5 per cent. dividend to the ordinary shareholders, to place £10,000 to a general reserve fund and to carry forward rather more than last year. With the present dislocation of world business and owing to foreign exchange difficulties and restrictions it was impossible to visualise the future, but the work on hand at the present time would keep most of the departments fairly busy for some time.

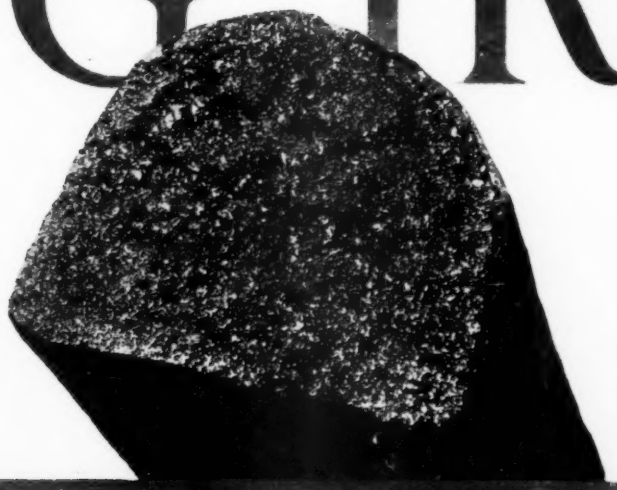
Some Experiences with the Balanced Blast Cupola.

(*Concluded from page* 21.)

thought out, and the number of rows of tuyeres, the number of tuyeres, their arrangement and their size, was governed by the experimental work that had been done and which showed the arrangement adopted to be necessary. The fact that Mr. Shepherd had to close the top row of tuyeres was part of the arrangement. The equipment provided was sufficiently elastic to permit adjustment to secure the precise air conditions required to suit any given fuel and type of charge. A striking feature of the cupola was that it had shown over and over again that the best conditions for melting metal, that was to say the hottest and cleanest metal, and the best running metal were arrived at when the cupola was being operated most economically. He did not recommend foundrymen to try to judge their cupola practice by comparing their coke consumption with that of another man. A ratio of 10 to 1 in one foundry might be very much more creditable than a ratio of 13 to 1 in another. Results must vary according to the type of charge and the type of coke used; even the size of the scrap became a consideration when coke economy was being discussed. Therefore he discouraged and distrusted comparisons of coke ratios between one plant and one foundry and another. The point was to get the best of which their cupola was capable. The balanced-blast cupola had reached as high a figure as 18½ to 1, and in his opinion 20 to 1 might be regarded as the theoretical limit for the type of fuel that it was possible to use.

XUM

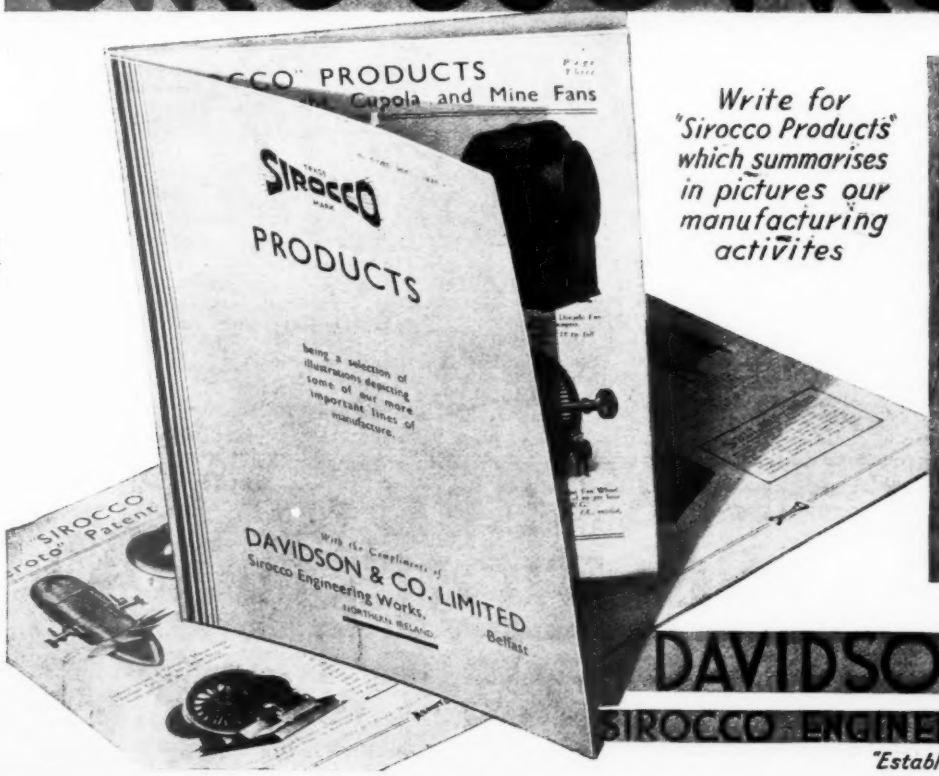
PIG IRON



Manufacturers of FOUNDRY, BASIC and HEMATITE qualities. Delivery from stock.
Booklet giving analyses, etc., will be sent on request.
DORMAN LONG & COMPANY LTD., MIDDLESBROUGH

DORMAN LONG

'SIROCCO' PRODUCTS



Write for "Sirocco Products" which summarises in pictures our manufacturing activites

Centrifugal & Propeller Fans. Aeroto (trade mark) Patent Screw Fans. Air Heaters, Washers and Automatic Air Conditioning Units. "Davidson" dust & flue dust Collectors. Pneumatic Conveying Plant etc. etc.

OUR ACCUMULATED EXPERIENCE IS AT YOUR SERVICE.

DAVIDSON & CO. LTD.
SIROCCO ENGINEERING WORKS, BELFAST
"Established in 1881"

Raw Material Markets.

Business in the iron and steel markets is slow to recover, the influence of the holidays still being felt, particularly in Scotland, while stock-taking operations at the works have also had a restrictive effect. The demand for finished steel continues to suffer by the inactivity prevalent in the shipbuilding and heavy engineering industries. The pig-iron markets have made a fairly good opening and the demand shows promise of expansion. The base-metal markets remain depressed, and low prices seem inevitable for some time to come.

Pig-Iron.

MIDDLESBROUGH.—More orders are now coming through to the makers, a number of consumers having covered their needs over the present quarter. Shipments to Scotland have been interrupted by the holidays. The official prices of Cleveland iron have now been unaltered for two years, during which period increasingly large rebates have been offered to Scottish and overseas buyers. The local consumers, however, are still called upon to pay the full rates, which are as follow:—No. 1 Cleveland foundry iron, 61s.; No. 3 Cleveland G.M.B., 58s. 6d.; No. 4 foundry, 57s. 6d.; No. 4 forge, 57s.

The East Coast hematite market is not showing a great deal of activity at the moment, but makers adhere to their prices, which are 59s. per ton for mixed numbers and 59s. 6d. for No. 1 quality. These prices are not likely to be reduced, in view of the rising cost of raw materials. Some of the merchants, however, who have heavy holdings, are cutting slightly below these quotations.

LANCASHIRE.—Business in this area has now shaken off holiday influences, but the demand is as yet very limited. Few of the Lancashire foundries can say that the state of their order books warrants entering into forward contracts, while finances are too tight at the moment to permit of speculative long-range stock-buying. For delivery to users in the Manchester price zone, Derbyshire, Staffordshire and Cleveland brands of No. 3 iron are maintained at 67s. per ton, Northamptonshire being at 65s. 6d., Derbyshire forge at 62s., Scottish foundry at about 82s. 6d. and East and West Coast hematite at 76s. and 81s. per ton, respectively.

MIDLANDS.—Many of the foundries only resumed work this week. They report that business has shown little improvement during the interval. One or two branches of the light-castings trade report a slight expansion. A fair number of consumers have now covered their requirements of pig-iron and will not be in the market again until the end of March. Foundry-iron prices remain at 62s. 6d. for Northants No. 3 and 66s. for North Staffordshire, Derbyshire and Lincolnshire No. 3, including delivery to Birmingham and Black Country stations. Only small supplies of Cleveland iron are coming through to this area.

SCOTLAND.—There has been a partial resumption of work in Scotland this week, but the position generally shows little improvement, and few of the foundries have restarted with satisfactory order books. Little new business in pig-iron has been transacted so far, and the market is still hanging fire. No. 3 Scottish foundry remains at 67s. 6d. per ton f.o.t. furnaces, with a minimum of 2s. 6d. extra for No. 1 grade. Cleveland No. 3 is at 54s. at Falkirk, Northamptonshire iron being about 1s. 6d. per ton less.

Coke.

The market for cupola coke remains dull. The demand is limited, forward buying being almost entirely absent. Best Durham fuel is offered delivered Birmingham at 36s. 6d. to 38s., Welsh coke varying from 30s. to 45s. per ton, according to analysis.

Steel.

Business in the steel markets has become more active, and, now that most firms have completed stocktaking, buying by home merchants and consumers has been resumed. The export markets also are showing more interest and there has been a fair amount of business transacted, although most of this has been for small tonnages for near delivery. The indications are that stocks abroad are low, but the works in this country and on the Continent are for the most part in a position to give early shipment, so that buyers feel safe in buying from hand to mouth. The demand for semi-finished material is moderately good and, with the exception of a few isolated transactions, the whole of the business formerly done with the Continent is now going to the British makers, although, in this department also, business is principally for near delivery. In the finished-steel department, there has been a certain amount of buying for stock replenishment, which is usual at this season, but the general home demand is irregular. Export business has shown signs of expanding lately, and, while the British works are increasing their export trade, a good proportion of the recent business has gone to the Continent.

Scrap.

The Cleveland market is definitely busy at the moment. Foundrymen are buying larger supplies of heavy metal at 40s. per ton, while machinery metal is in active request at 43s. A steady trade is being done on the Midland market. Heavy machinery cast-iron scrap in handy sizes is quoted at 47s. 6d. and clean light metal at 36s. per ton, delivered works. In South Wales good cast-iron machinery scrap is in limited demand at 47s. 6d., there being little improvement in the situation at the local foundries. In Scotland there is a much firmer market for scrap, machinery metal, in pieces not exceeding 1 cwt., being at 45s. to 46s. 3d., with ordinary cast iron to the same specification at about 5s. less.

Metals.

Copper.—Business with consumers has lately been retarded by stock-taking activities at the works, but the demand can now be regarded as taking its normal course. The level of buying at the moment is not very encouraging; consumers are strictly limiting themselves to immediate requirements. This attitude is to a large extent due to the failure of the producers to agree on output curtailment, as the metal is certainly very cheap at the moment. Even cheaper prices would ensue, however, if there is the "price war" which is predicted in certain quarters.

Prices have been:—

Cash.—Thursday, £28 3s. 9d. to £28 6s. 3d.; Friday, £28 5s. to £28 7s. 6d.; Monday, £28 16s. 3d. to £28 17s. 6d.; Tuesday, £28 17s. 6d. to £29; Wednesday, £29 10s. to £29 12s. 6d.

Three Months.—Thursday, £28 11s. 3d. to £28 13s. 9d.; Friday, £28 12s. 6d. to £28 13s. 9d.; Monday, £29 2s. 6d. to £29 3s. 9d.; Tuesday, £29 5s. to £29 6s. 3d.; Wednesday, £29 17s. 6d. to £29 18s. 9d.

Tin.—There has been a certain reaction from last week's break in the price of tin, following support by the controlling interests. There was also a certain amount of buying by consumers at the lower levels, particularly by the tinplate manufacturers, who took up considerable tonnages. The recent burst of selling was caused by the disappointing nature of the estimates of the total visible supplies at the end of the year. World stocks continue to increase, while deliveries show proportionate contraction. The two months' cessation of output has had little effect upon the general situation.

Prices of standard tin have been:—

Cash.—Thursday, £144 5s. to £144 10s.; Friday, £144 5s. to £144 10s.; Monday, £145 5s. to £145 10s.; Tuesday, £146 7s. 6d. to £146 10s.; Wednesday, £147 5s. to £147 7s. 6d.

Three Months.—Thursday, £145 5s. to £145 10s.; Friday, £145 to £145 5s.; Monday, £146 to £146 5s.; Tuesday, £146 17s. 6d. to £147; Wednesday, £147 17s. 6d. to £148.

Spelter.—The reasons for the present low price of this metal are the poor demand from users and the uncertainty with regard to the future of the Cartel. Otherwise, output has been carefully controlled, stocks of unsold metal have progressively decreased, and the tonnage remaining is firmly held, as the "bull account" was considerably reduced last year. Thus, the technical position of the market at the beginning of the year was quite satisfactory. Reports are now circulating, however, of internal dissension amongst the members of the Cartel, one or two of whom, it is stated, are considering extending their production beyond their allocated quota, the agreed penalty for which is only one gold shilling per ton. The possibility of such an action is considerably disturbing the market. Any improvement in the trade demand, however, would quickly strengthen the situation.

Price fluctuations:—

Ordinary.—Thursday, £14 11s. 3d.; Friday, £14 11s. 3d.; Monday, £14 15s.; Tuesday, £14 12s. 6d.; Wednesday, £14 16s. 3d.

Lead.—The industrial demand for lead remains slow. Lack of support is particularly noticeable from the cable-makers, and also from the building trades, which have been badly hit by the general depression. The immediate outlook is rather undecided.

Daily market prices:—

Soft Foreign (Prompt).—Thursday, £10 18s. 9d.; Friday, £10 5s.; Monday, £10 6s. 3d.; Tuesday, £10 5s.; Wednesday, £10 10s.

Nitricastiron.

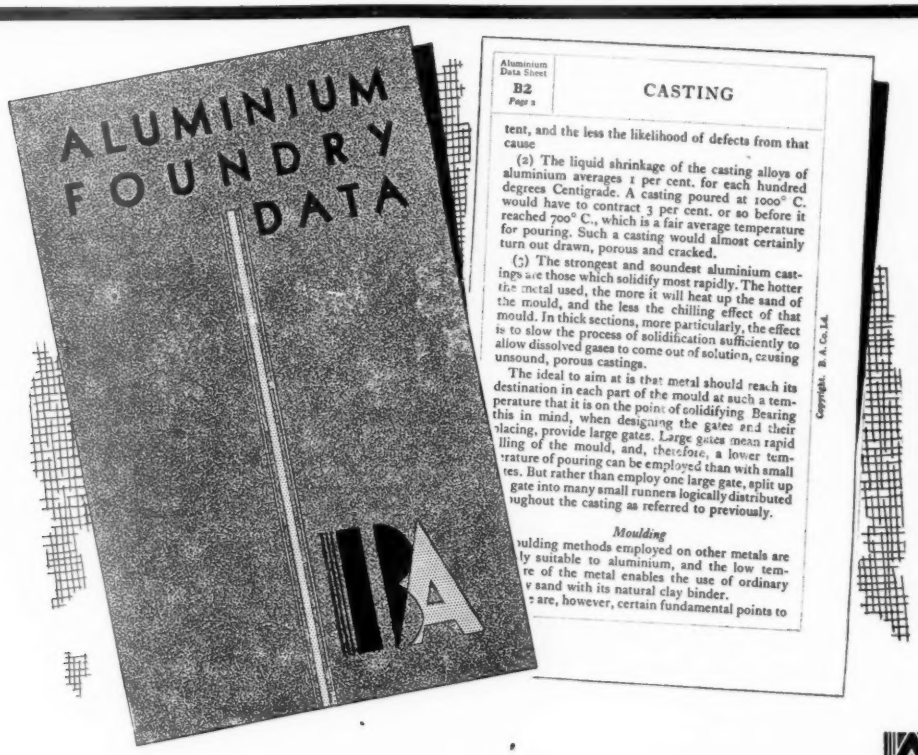
(*Concluded from page* 20.)

designer to obtain higher m.p.g., and that had been the cause of corresponding stresses. He did not want to enter into a discussion on the theory of cylinder wear beyond just confirming what he had already said—that it was largely the stresses that existed in the cylinder that caused the wear, and consequently the designers and metallurgists had been called upon to produce designs and materials in which the effect of those stresses were minimised. Nitricastiron was one of the answers of the metallurgists.

Vote of Thanks.

MR. SCOTT, in proposing a vote of thanks to Mr. Hurst, said that they must apologise to Mr. Hurst for getting away from the subject of his Paper, but in that district they did not know a great deal about Nitricastiron, so they were unable to ask many metallurgical questions about it. The vote of thanks was seconded by MR. DAWSON and passed unanimously. MR. HURST briefly replied.

CAST IRON FLANGED PIPES
2 in.—12 in. & CONNECTIONS. to 24 in. dia.
WE HAVE FIFTY-TWO YEARS OF ACCUMULATED EXPERIENCE AND METAL PATTERNS.
JAMES & RONALD RITCHIE, LTD.,
Telephone: 3852 (2 Lines). MIDDLESBROUGH. Telegrams: "Ritchie, Middlesbrough."


ALUMINIUM
FOUNDRY
DATA
BA
Aluminium Data Sheet
B2
Page 3
CASTING
tent, and the less the likelihood of defects from that cause
(2) The liquid shrinkage of the casting alloys of aluminium averages 1 per cent. for each hundred degrees Centigrade. A casting poured at 1000° C. would have to contract 3 per cent. or so before it reached 700° C., which is a fair average temperature for pouring. Such a casting would almost certainly turn out drawn, porous and cracked.
(3) The strongest and soundest aluminium castings are those which solidify most rapidly. The hotter the metal used, the more it will heat up the sand of the mould, and the less the chilling effect of that mould. In thick sections, more particularly, the effect is to slow the process of solidification sufficiently to allow dissolved gases to come out of solution, causing unsound, porous castings.
The ideal to aim at is that metal should reach its destination in each part of the mould at such a temperature that it is on the point of solidifying Bearing this in mind, when designing the gates and their placing, provide large gates. Large gates mean rapid filling of the mould, and, therefore, a lower temperature of pouring can be employed than with small gates. But rather than employ one large gate, split up the gate into many small runners logically distributed throughout the casting as referred to previously.
Moulding
Moulding methods employed on other metals are equally suitable to aluminium, and the low temperature of the metal enables the use of ordinary moulding sand with its natural clay binder.
There are, however, certain fundamental points to
Copyright. B. A. Co. Ltd.

Light aluminium alloys, ready mixed to B.A. Co., British Standard and special specifications, are available to the founder in the well-known B.A. Co. three-division ingot form. For B.A. Co. virgin aluminium, of 98/99% and higher purities, the familiar form is the 15" notched bar, weighing 3¼ lbs.

★ Aluminium foundrymen are invited to write for current B.A.C. Aluminium Foundry Data (No. 328).

ALUMINIUM AND LIGHT ALLOYS
THE BRITISH ALUMINIUM Co LTD.
ADELAIDE HOUSE, KING WILLIAM STREET, LONDON, E.C.4.
TELEPHONE: MANSION HOUSE 5561 & 0074 (5 LINES) TELEGRAMS: CRYOLITE, BILGATE, LONDON.

F.T.J. 12.1.33.

WARNER C.I.P.R.
CYLINDER
PIG IRON
"The brand of proved reliability"
Supplied to specifications covering a wide range of requirements and employed by the leading Railway Co's Roll Makers and Engineering Founders.
WARNER & CO. LIMITED
CARGO FLEET MIDDLESBROUGH

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	29	10	0
Three months	29	17	6
Electrolytic	34	7	6
Tough	30	15	0
Best selected	31	5	0
Sheets	61	0	0
India	41	10	0
Wire bars	33	17	6
Do., Feb.	34	10	0
Do., March	34	5	0
Ingot bars	33	17	6
H.C. wire rods	36	15	0
Off. av. cash, December	29	2	7¼
Do., 3 mths., December	29	9	7⅝
Do., Sttlmnt., December	29	2	4½
Do., Electro, December	34	12	2¼
Do., B.S., December	32	3	7½
Do., wire bars, December	34	17	6
Solid drawn tubes			9½d.
Brazed tubes			9¼d.
Wire			6½d.

BRASS.

Solid drawn tubes	8⅞d.
Brazed tubes	10¼d.
Rods, drawn	7¾d.
Rods, extd. or rlld.	4¾d.
Sheets to 10 w.g.	7½d.
Wire	7½d.
Rolled metal	7d.
Yellow metal rods	4½d.
Do. 4 × 4 Squares	5½d.
Do. 4 × 3 Sheets	5½d.

TIN.

	£	s.	d.
Standard cash	147	5	0
Three months	147	17	6
English	148	10	0
Bars	150	0	0
Straits	151	7	6
Australian	149	7	6
Eastern	152	5	0
Banca	152	7	6
Off. av. cash, December	149	17	9¾
Do., 3 mths., December	151	1	0¾
Do., Sttlmt., December	149	18	6

SPELTER.

	£	s.	d.
Ordinary	14	16	3
Remelted	14	10	0
Hard	12	10	0
Electro 99.9	17	10	0
English	15	12	6
India	14	10	0
Zinc dust	22	0	0
Zinc ashes	2	15	0
Off. aver., December	15	5	6¾
Aver. spot, December	15	4	2¼

LEAD.

	£	s.	d.
Soft foreign ppt.	10	10	0
Empire	10	11	3
English	12	0	0
Off. average, December	11	6	10½
Average spot, December	12	2	10½

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	24	10	0
Do., V.M. ex-whse.	24	5	0
Rods	27	0	0
Boiler plates	23	0	0
Battery plates			—

ANTIMONY.

	£	s.	d.	£	s.	d.
English	37	10	0 to	42	10	0
Chinese				27	5	0
Crude				19	10	0

QUICKSILVER.

	£	s.	d.
Quicksilver	10	10	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
25%	£7 17 6
45/50%	£14 0 0
75%	£19 10 0
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free of Mo.	6/3 per lb.
Ferro-titanium—	
23/25% carbon-free	9½d. lb.
Ferro-phosphorus, 20/25%	£18 2 6
Ferro-tungsten—	
80/85%	1/7½ lb.
Tungsten metal powder—	
98/99%	1/10½ lb.
Ferro-chrome—	
2/4% car.	£31 10 0
4/6% car.	£24 0 0
6/8% car.	£23 2 6
8/10% car.	£21 0 0
Ferro-chrome—	
Max. 2% car.	£35 2 6
Max. 1% car.	£36 5 0
Max. 0.70% car.	£41 2 6
70% carbon-free	11d. lb.
Nickel—99.5/100%	£250 to £255
"F" nickel shot	£225 0 0
Ferro-cobalt	7/3 lb.
Aluminium 98/99%	£100 0 0
Metallic chromium—	
96/98%	2/8 lb.
Ferro-manganese (net)—	
76/80% loose	£10 15 0 to £11 5 0
76/80% packed	£11 15 0 to £12 5 0
76/80% export	(nom.) £9 15 0
Metallic manganese—	
94/96% carbon-free	1/1 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 7/32 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP.

	£	s.	d.	£	s.	d.
South Wales—						
Heavy steel				2	0	0
Bundled steel and shrngs.	1	15	0 to	1	17	6
Mixed iron and steel	1	14	0 to	1	16	6
Heavy cast iron				2	2	6
Good machinery				2	7	6
Cleveland—						
Heavy steel				2	0	0
Steel turnings				1	12	6
Cast-iron borings				1	3	6
Heavy forge				2	10	0
W.I. piling scrap				2	2	6
Cast-iron scrap	2	0	0 to	2	3	0
Midlands—						
Light cast-iron scrap				1	16	0
Heavy wrought iron				2	5	0
Steel turnings, f.o.r.				1	0	6
Scotland—						
Heavy steel	1	15	0 to	1	17	6
Ordinary cast iron				2	0	0
Engineers' turnings				1	10	0
Cast-iron borings				1	10	6
Wrought-iron piling				2	0	0
Heavy machinery				2	5	6

London—Merchants' buying prices delivered yard.

	£	s.	d.
Copper (clean)	21	0	0
Brass	14	0	0
Lead (less usual draft)	9	0	0
Tea lead	7	10	0
Zinc	8	10	0
New aluminium cuttings	72	0	0
Braziery copper	19	0	0
Gunmetal	18	0	0
Hollow pewter	80	0	0
Shaped black pewter	60	0	0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast—	
Foundry No. 1	61/-
Foundry No. 3	58/6
,, at Falkirk	54/-
Foundry No. 4	57/6
Forge No. 4	57/-
Hematite No. 1	59/6
Hematite M/Nos.	59/-
N.W. Coast—	
Hem. M/Nos. d/d Glas.	69/-
,, d/d Birm.	84/6
Malleable iron d/d Birm.	117/6
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	61/-
,, No. 3 fdry.	66/-
Northants forge	57/6
,, fdry. No. 3	62/6
,, fdry. No. 1	65/6
Derbyshire forge	61/-
,, fdry. No. 3	66/-
,, fdry. No. 1	69/-
,, basic	—
Scotland—	
Foundry No. 1	70/-
,, No. 3	67/6
Hem. M/Nos. d/d	66/-
Sheffield (d/d district)—	
Derby forge	58/6
,, fdry. No. 3	63/6
Lincs forge	—
,, fdry. No. 3	63/6
E.C. hematite	73/6
W.C. hematite	83/6
Lancashire (d/d eq. Man.)—	
Derby forge	62/-
,, fdry. No. 3	67/-
Staffs fdry. No. 3	67/-
Northants fdry. No. 3	65/6
Cleveland fdry. No. 3	67/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	82/6
Clyde, No. 3	82/6
Monkland, No. 3	82/6
Summerlee, No. 3	82/6
Eglinton, No. 3	82/6
Gartsherrie, No. 3	82/6
Shotts, No. 3	82/6

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)	9	0	0 to	9	15	0
Nut and bolt iron	7	15	0 to	8	0	0
Hoops	10	10	0 to	12	0	0
Marked bars (Staffs) f.o.t.				12	0	0
Gas strip	10	10	0 to	12	0	0
Bolts and nuts, ¾ in. × 4 in.				13	0	0
Steel—						
Plates, ship, etc.	8	15	0 to	8	17	6
Boiler plts.	8	0	0 to	9	0	0
Chequer plts.				10	7	6
Angles				8	7	6
Tees				9	7	6
Joists				8	15	0
Rounds and squares, 3 in. to 5½ in.				9	7	6
Rounds under 3 in. to ¼ in. (Untested)	8	15	0 & up.			
Flats—8 in. wide and over				8	12	6
,, under 8 in. and over 5 in.				8	17	6
Rails, heavy	8	5	0 to	8	10	0
Fishplates				12	0	0
Hoops (Staffs)	9	10	0 to	10	10	0
Black sheets, 24g. (10-t. lots)				9	10	0
Galv. cor. shts. ,,				11	15	0
Galv. flat shts. ,,				12	5	0
Galv. fencing wire, 8g. plain				14	0	0
Billets, soft	4	17	6 to	5	7	6
Billets, hard	6	12	6 to	7	2	6
Sheet bars	4	15	0 to	5	2	6
Tin bars				4	15	0

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	10½d.
Sheet to 10 w.g.	11½d.
Wire	11⅜d.
Rods	10½d.
Tubes	16d.
Castings	12½d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	13.34
No. 2 foundry, Valley	14.50
No. 2 foundry, Birm.	11.00
Basic	15.39
Bessemer	16.89
Malleable	16.39
Grey forge	16.39
Ferro-mang. 80%, seaboard	68.00
O.-h. rails, h'y, at mill	40.00
Billets	26.00
Sheet bars	26.00
Wire rods	37.00
	Cents.
Iron bars, Phila.	1.86
Steel bars	1.60
Tank plates	1.60
Beams, etc.	1.60
Skelp, grooved steel	1.60
Steel hoops	1.55
Sheets, black, No. 24	2.10
Sheets, galv., No. 24	2.85
Wire nails	1.95
Plain wire	2.20
Barbed wire, galv.	2.60
Tinplates, 100-lb. box	$4.75

COKE (at ovens).

Welsh foundry	20/- to 22/6
,, furnace	16/- to 16/6
Durham and Northumberland—	
,, foundry	21/- to 25/-
,, furnace	13/6 to 13/9
Midlands, foundry	—
,, furnace	—

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box	16/-
,,	28×20 ,,	32/-
,,	20×10 ,,	23/-
,,	18¾×14 ,,	16/7½
C.W.	20×14 ,,	14/-
,,	28×20 ,,	29/3 to 29/6
,,	20×10 ,,	19/10
,,	18¾×14 ,,	14/-

SWEDISH CHARCOAL IRON & STEEL.

Pig-iron	£6	0	0 to	£7	0	0
Bars-hammered, basis	£16	10	0 to	£17	0	0
Bars and nail-rods, rolled, basis	£15	17	6 to	£16	5	0
Blooms	£10	0	0 to	£12	0	0
Keg steel	£32	0	0 to	£33	0	0
Faggot steel	£18	0	0 to	£23	0	0
Bars and rods dead soft, st'l	£10	0	0 to	£12	0	0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.		
Jan.	5 ..	28	3	9	inc.	2/6
..	6 ..	28	5	0	..	1/3
..	9 ..	28	16	3	..	11/3
..	10 ..	28	17	6	..	1/3
..	11 ..	29	10	0	..	12/6

Electrolytic Copper.

		£	s.	d.		
Jan.	5 ..	32	15	0	dec.	10/–
..	6 ..	33	12	6	inc.	17/6
..	9 ..	33	10	0	dec.	2/6
..	10 ..	33	15	0	inc.	5/–
..	11 ..	34	7	6	..	12/6

Standard Tin (cash).

		£	s.	d.		
Jan.	5 ..	144	5	0	inc.	65/–
..	6 ..	144	5	0	No change	
..	9 ..	145	5	0	inc.	20/–
..	10 ..	146	7	6	..	22/6
..	11 ..	147	5	0	..	17/6

Tin (English ingots).

		£	s.	d.		
Jan.	5 ..	145	10	0	inc.	65/–
..	6 ..	145	5	0	dec.	5/–
..	9 ..	146	10	0	inc.	25/–
..	10 ..	147	10	0	..	20/–
..	11 ..	148	10	0	..	20/–

Spelter (ordinary).

		£	s.	d.		
Jan.	5 ..	14	11	3	inc.	2/6
..	6 ..	14	11	3	No change	
..	9 ..	14	15	0	inc.	3/9
..	10 ..	14	12	6	dec.	2/6
..	11 ..	14	16	3	inc.	3/9

Spelter (Electro, 99.9 per cent.).

		£	s.	d.		
Jan.	5 ..	17	5	0	inc.	5/–
..	6 ..	17	5	0	No change	
..	9 ..	17	10	0	inc.	5/–
..	10 ..	17	10	0	No change	
..	11 ..	17	10	0	..	..

Zinc Sheets (English).

		£	s.	d.	
Jan.	5 ..	24	10	0	No change
..	6 ..	24	10	0	.. ..
..	9 ..	24	10	0	.. ..
..	10 ..	24	10	0	.. ..
..	11 ..	24	10	0	.. ..

Lead (English).

		£	s.	d.		
Jan.	5 ..	12	0	0	No change	
..	6 ..	11	15	0	dec.	5/–
..	9 ..	11	15	0	No change	
..	10 ..	11	15	0	..	..
..	11 ..	12	0	0	inc.	5/–

AVERAGE MONTHLY PRICES OF STEEL SHIP ANGLES (NORTH OF ENGLAND).

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1897	5 7 6	5 7 6	5 7 6	5 5 0	5 0 0	5 0 0	5 2 6	5 2 6	5 2 6	5 2 6	5 0 0	5 0 0	5 3 5½
1898	5 5 0	5 5 0	5 5 0	5 7 6	5 13 9	5 15 0	5 15 0	5 15 0	5 17 6	6 0 0	6 5 0	6 7 6	5 14 3
1899	6 10 0	6 12 6	6 15 0	6 15 0	6 17 6	7 0 0	7 0 0	7 5 0	7 5 0	7 5 0	7 12 6	7 15 0	7 0 5
1900	7 15 0	8 0 0	8 2 6	8 5 0	8 5 0	8 7 6	8 7 6	8 2 6	8 2 6	8 0 0	7 10 0	7 10 0	8 0 7½
1901	6 15 0	6 12 6	6 5 0	6 0 0	6 0 0	5 10 0	5 15 0	5 17 6	6 0 0	5 17 6	5 17 6	5 15 0	6 0 5
1902	5 12 6	5 10 0	5 10 0	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 7 6	5 11 8
1903	5 6 3	5 7 6	5 7 6	5 12 6	5 12 6	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 0 0	5 8 9
1904	5 0 0	4 17 6	5 2 6	5 5 0	5 5 0	5 5 0	5 5 0	5 5 0	5 0 0	5 0 0	5 0 0	5 5 0	5 2 6
1905	5 5 0	5 7 6	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 12 6	6 2 6	6 12 6	6 12 6	5 14 4½
1906	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	7 2 6	6 13 4
1907	6 17 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	6 12 6	7 0 5	
1908	6 2 6	6 2 6	6 2 6	5 17 6	5 17 6	5 17 6	5 17 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 16 3
1909	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 9 7
1910	5 16 3	5 17 6	5 17 6	6 1 6	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	6 7 6	6 7 6	6 7 6	6 2 3½
1911	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 9 0	6 7 8½
1912	6 16 3	6 17 6	6 17 6	7 5 0	7 7 6	7 7 6	7 7 6	7 12 6	7 12 6	7 12 6	7 14 6	7 17 6	7 7 4½
1913	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 11 6	7 7 6	6 15 6	6 7 6	6 2 6	7 8 11½
1914	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	5 15 0	5 15 0	6 15 0	7 0 0	7 0 0	7 1 3	7 5 0	6 8 7½
1915	7 17 0	8 5 0	8 17 6	9 5 0	9 15 0	9 15 0	9 15 0	9 15 0	9 15 0	9 15 0	10 15 0	10 15 0	9 8 3½
1916	11 3 1½	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6
1917	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6
1918	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6½
1919	11 2 6	13 12 6	13 12 6	13 12 6	17 2 6	17 1 3	17 0 0	17 15 0	17 15 0	17 15 0	17 17 6	18 5 0	16 1 9
1920	19 10 0	20 0 0	21 10 0	22 0 0	23 5 0	24 0 0	24 0 0	24 0 0	24 15 0	24 10 0	24 0 0	24 0 0	22 19 2
1921	22 10 0	20 12 6	19 0 0	17 10 0	17 10 0	16 6 0	14 10 0	14 3 4	13 10 0	11 15 0	10 0 0	9 12 6	15 11 7
1922	9 17 6	10 0 0	10 0 0	10 0 0	10 0 0	9 17 6	9 10 0	8 15 7½	8 14 0	8 12 6	8 12 6	8 12 6	9 7 8½
1923	8 18 1½	9 1 3	9 14 0	10 0 0	10 0 0	10 0 0	9 8 9	9 9 6	9 10 0	9 8 9	9 11 6	9 18 9	9 11 8½
1924	10 0 0	9 18 1½	9 17 6	9 17 6	9 17 2	9 11 3	9 15 0	9 15 0	9 9 4½	9 6 6	9 5 0	9 5 0	9 13 1½
1925	9 2 0	9 0 11½	9 0 0	8 15 9	8 10 3½	8 9 0½	8 6 3	8 2 6	7 19 0½	7 12 3	7 5 0	7 2 6	8 5 5½
1926	7 2 6	7 2 6	7 2 6	7 3 4	7 2 6	7 3 9	7 7 6	7 8 5½	7 9 0	7 12 6	7 16 3	8 0 6	7 7 7½
1927	7 18 9	7 17 6	7 17 6	7 14 8½	7 13 9	7 12 6	7 12 6	7 12 6	7 12 6	7 12 6	7 12 6	7 12 6	7 14 1½
1928	7 12 6	7 14 9	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 16 10½
1929	7 17 6	7 17 6	7 17 6	7 17 6	8 0 6	8 2 6	8 2 6	8 2 6	8 2 6	8 2 6	8 2 6	8 5 0	8 0 10½
1930	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6
1931	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6
1932	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6

WILLIAM JACKS & COMPANY,

WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

CLARENCE CHAMBERS, 39, CORPORATION STREET, BIRMINGHAM.

13, RUMFORD STREET, LIVERPOOL.

PIG IRON

REGISTERED TRADE MARK

All grades FOUNDRY, HEMATITE, BASIC, SPECIALS, &c.

NON-FERROUS METALS

COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

WILLIAM JACKS & COMPANY,

CENTRAL CHAMBERS, 93, HOPE ST., GLASGOW, C.2.

ZETLAND ROAD, MIDDLESBROUGH.

XUM

SMALL ADVERTISEMENTS.

Notice.

Small Advertisements in this section of the Journal are accepted at the prepaid rate of 6d. per line, first line in capitals counting two, average 6 words per line. Minimum charge for one insertion 3/-

(A remittance should accompany instructions.)

SITUATIONS VACANT AND WANTED.

ADVERTISER desires position as Foundry Manager or Foreman; practical, technical and commercial training all branches foundry work, thorough knowledge of metallurgy and mixing of metals; can take entire charge.—Box 318, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

BRASS FOUNDRY FOREMAN desires position; experienced in Admiralty contracts, gunmetal, phos. bronze and manganese castings; 12 years foreman in last situation.—Box 258, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

EMPLOYMENT REGISTER.

Conducted by the Institute of British Foundrymen by courtesy of the proprietors of THE FOUNDRY TRADE JOURNAL.

Correspondence should be addressed to the General Secretary, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, from whom full particulars can be obtained of this service.

Any employer wishing to communicate with a candidate should write to the General Secretary, quoting identification number.

PRACTICAL Foundryman seeks situation in any sphere of foundry activity. Excellent character, secondary education. Contributor to foundry literature, many educational successes. Preferably situation of trust and responsibility. Representative foundry requisites. Anything considered; not afraid of work. (201)

FIRST-CLASS Steel-Foundry Manager requires similar position, or in any other capacity where experience could be utilised. Sound engineering training, practical steel-making, experience including electric steel and subsequent manager of well-known steel foundries. (262)

YOUNG Moulder, 19 years of age, requires position. Good experience on special pipes and similar castings. (203)

PRACTICAL Foundry Manager desires engagement. Wide and varied experience, machine tools, light castings, turbine and engine work. Rotary furnace experience. (204)

WORK WANTED.

MARSHALL'S Foundries have up-to-date equipment, thoroughly experienced staff, laboratory and patternmaking services, and are prepared to supply high-class castings, specials or repetition work. All classes of iron, semi-steel and nickel-iron, large or small castings. All classes of brass, bronze, aluminium and other non-ferrous castings to specification. Quick deliveries guaranteed.—MARSHALL, SONS & COMPANY, LIMITED, Gainsborough, Lincs.

PROPERTY.

HENDON DISTRICT.—Engineers moving North have for disposal Modern Foundry, fully equipped and ready to start. Ample room for extension. Machine shop. Low price for quick sale.—Box 226, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

PROPERTY—*Continued.*

MAGNIFICENT

11 ACRES WORKS SITE.

SHEFFIELD.

145,000 Sq. Ft. of Shops.

SIDING CONNECTIONS

with L.M. & S. and L. & N.E. Rlys.

WELL-BUILT & COMMODIOUS OFFICES

Will Sell whole or in lots to suit customers or Let on favourable terms. Unique opportunity for Manufacturers.

Apply—

THOS. W. WARD, LTD.,

ALBION WORKS, SHEFFIELD.

PUBLICATION

RYLAND'S DIRECTORY of the Coal, Iron, Steel, Tinplate, Metal, Engineering, Hardware and Allied Trades. 1932 edition. Price 42s., bound in cloth.—INDUSTRIAL NEWSPAPERS, LTD., 49, Wellington Street, Strand, London, W.C.2.

MACHINERY.

ELEC. Travelling Wharf Crane. All motions. Cheap.—A. MORGAN, 50, Wilkin Street, N.W.5. Gul. 1147

S. C. BILSBY, A.M.I.C.E., A.M.I.E.E.

Carries a large stock of **FOUNDRY PLANT** which, generally, includes :—

Power and Hand Moulding Machines, Sand Mills and Disintegrators, Sand Blast Plants, Ladles, Melting Furnaces, Grinding Machines, Blowers and Exhaust Fans, Air Compressors, etc., etc.

Also 300 A.C. and D.C. Electric Motors, ¼ to 200 h.p., and Generators, to suit most systems.

All at low prices. Please send your inquiries to :—

215, BARCLAY ROAD, WARLEY,

Nr. Birmingham.

'Phone : Bearwood 1103.

WORKS ADDRESS : Crosswells Road (next G.W.R. level crossing), Langley, near Birmingham. 'Phone : Broadwell 1359.

MORRIS Cupola Hoist with Steel Tower and Car.—A. MORGAN, 50, Wilkin Street, N.W.5. Gul. 1147.

THOS. W. WARD, LTD.

HYDRAULIC PUMPS, Vert. 3-throw geared, 2" rams x 6" str., 1,500 lbs. press.

MOTOR, 60 h.p., 220 volts, 1,450 revs. By Brit. West. Co.

PLANING MACHINE, Hand and Power Feed, cap. 16" x 9", will surface 18".

3 LANCS BOILERS, 30' x 8', 150 lbs. w.p.

VERT. COCHRAN BOILER, 14' x 7', 100 lbs. w.p.

Write for "Albion" Catalogue.

'Grams : "Forward, Sheffield."

'Phone : 23001 (10 lines).

ALBION WORKS, SHEFFIELD.

MISCELLANEOUS.

FOUNDRY SPRIGS, English, fine cut, now further reduced. Please write us for carriage-paid rates, stating quantities.—WILLIAM OLSEN, LIMITED, Cogan Street, Hull.

SPRIGS (fine cut) at cut prices; 3 in. to 6 in., £11 10s. ton d/d any station England, or 11s. 6d. cwt., carriage extra.

Inquiries esteemed.

ROBERTS METALLURGICAL COMPANY, 30, Ravenswood Road, Balham, London, S.W.

MISCELLANEOUS—*Continued*

'Phone 287 SLOUGH

HAND MOULDING MACHINES

Six Standard "Adaptable" machines £12 each

Two "LARGE" Adaptables (take 30"×30") ... ... £15 each

24"×30" Darling & Sellars turnover £15

Two 18"×16" Coventry HEADRAM squeezers ... ... £18 each

PNEUMATIC MACHINES

14"×16" Tabor split pattern ... £30

18"×18" Tabor split pattern ... £40

30"×20" Macdonald jolt rollover... £60

20"×16" Macdonald jolt rollover... £40

AIR COMPRESSORS ALL SIZES IN STOCK.

Every Machine overhauled and retested.

BUY FROM ME AND SAVE MONEY!

ALEX. HAMMOND, *Foundry Machinery Merchant,*

14, AUSTRALIA ROAD, SLOUGH

BRISTOL

To Engineers, Founders, Manufacturers. Fine site of nearly 3 acres on Arterial Road with Foundry and Workshops and own Rail Sidings into premises. Modern Offices, Warehouse and Workrooms. Central Heating.

CHARLES A. TRICKS & SON, Auctioneers, ST. NICHOLAS STREET, BRISTOL.

FOUNDRY SPECIALISTS

Core Oils, Compounds and Binders, Plumbagoes, Parting Powders, etc. "Puric" Fluxes for Cupola work. Also for Brass and Bronze.

SULRON "X" FLUX for Iron and Steel.

"INOKULITE" for Iron and Steel Refinement.

"ALSICA" POWDER for Heads of Ingots and Castings.

Coaldust, Foundry Blackings, Chaplets, Studs, Foundry Equipment, etc., etc.

REFRACTORIES OF EVERY DESCRIPTION.

British Foundry Units, Ltd.

Incorporating Foundry Materials and Products Dept. of Beecroft and Partners, Ltd.
Incorporating Foundry Requisites and Chesterfield Blacking Works of J. & J. Dyson, Ltd.

RETORT WORKS, CHESTERFIELD.

RYLAND'S DIRECTORY

[2,200 pages 8½" × 5½"].

The standard work of reference covering the Coal, Iron, Steel, Tinplate, Metal, Engineering, Hardware and Allied Trades.

1932 EDITION.

ORDER YOUR COPY NOW.
PRICE **42/-** *BOUND IN CLOTH.*

INDUSTRIAL NEWSPAPERS, Ltd.
49, Wellington St., Strand, London, W.C.2.

Telephone : Temple Bar 3951 (5 lines).